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THE

ENCYCLOPÆDIA BRITANNICA,

OR

DICTIONARY

OF

ARTS, SCIENCES, AND GENERAL LITERATURE.

EIGHTH EDITION.

WITH EXTENSIVE IMPROVEMENTS AND ADDITIONS;
AND NUMEROUS ENGRAVINGS.

VOLUME XVI.

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ENCYCLOPÆDIA BRITANNICA.

NAVIGATION.

History. NAVIGATION is the art of conducting a ship from one port or place to another.

HISTORY.

The profane poets refer the invention of the art of navigation to their heathen deities, though historians ascribe it to the Æginetes, the Phœnicians, the Tyrians, and the ancient inhabitants of Britain. Scripture refers the origin of so useful an invention to God himself, who gave the first specimen of navigation in the ark built by Noah under his direction.

The earliest record of the practice of the art of navigation is that of the Egyptians, who at a very remote period are said to have established commercial relations with India. This traffic was carried on between the Arabian Gulf and the western coast of India, across the Indian Ocean. It would appear, however, that this intercourse was of no long duration, and that the Egyptians soon confined themselves to overland traffic with their neighbours, even excluding from all access to their country those foreigners who would have traded with them by the Mediterranean Sea.

The Phœnicians were the most distinguished of the early navigators; their commercial relations with other nations were the most widely spread; and their capital, Tyre, was for ages the centre of ancient commerce and the "mart of nations." The narrowness and poverty of the little slip of ground they possessed along the coast, and the convenience of two or three good ports, naturally drove an enterprising and industrious people, stimulated by a genius for commerce, to seek by sea those riches which were denied them by land. Accordingly, Lebanon and the other neighbouring mountains furnishing them with excellent wood for ship-building, they in a short time became masters of a numerous fleet; and constantly hazarding new navigations, and settling new trades, they soon arrived at an incredible pitch of opulence and populousness, insomuch as to be in a condition to send out colonies. The principal of these was Carthage, which, keeping up the Phœnician spirit of commerce, in time not only equalled Tyre itself, but vastly surpassed it, sending its merchant fleets through the Straits of Gibraltar, along the western coasts of Africa and Europe, and even, if we may believe some authors, to America itself. History.

At an early period of their history, although long subsequently to the rise of the Phœnician navigators, the Greeks learned and practised the art of navigating the adjacent seas, although they seem to have trusted almost entirely to the oar as the instrument of propulsion. The celebrated voyage of the Argonauts belongs to a very early period; and in later times the Corinthians and Corcyræans disputed with Athens the empire of the Greek seas. At length Tyre, whose immense riches and power are represented in such lofty terms both by sacred and profane authors, was destroyed by Alexander the Great, upon which its navigation and commerce were transferred by the conqueror to Alexandria, a new city, admirably situated for these purposes, and intended to form the capital of the empire of Asia, of which Alexander then meditated the conquest. And thus arose the great navigation of the Egyptians, which was afterwards so much cultivated by the Ptolemies, that Tyre and Carthage were quite forgotten.

Egypt being reduced to a Roman province after the battle of Actium, its trade and navigation fell into the hands of Augustus, in whose time Alexandria was only inferior to Rome; and the magazines of the capital of the world were wholly supplied with merchandise from the commercial capital of Egypt.

At length Alexandria itself underwent the fate of Tyre and Carthage, being surprised by the Saracens, who, in spite of the Emperor Heraclius, overspread the northern coast of Africa. By them the merchants were expelled, and Alexandria was, until lately, in a languishing state; though it always had a considerable share of the commerce of the Christian merchants trading to the Levant. A fresh impulse, however, has been given of late years to the trade of Alexandria by its having become an important post in the overland route to India.

The fall of Rome and its empire drew along with it not only the overthrow of learning and the polite arts, but also that

History. of navigation; the barbarians, into whose hands it fell, contenting themselves with the spoils of the industry of their predecessors. But no sooner were the braver amongst those nations well settled in their new provinces,—some in Gaul, as the Franks; others in Spain, as the Goths; and others in Italy, as the Lombards,—than they began to learn the advantages of navigation and commerce, and the methods of managing them, from the people they had subdued; and this with so much success, that in a little time some of them became able to give new lessons, and set on foot new institutions for its advantage. Thus it is to the Lombards that we usually ascribe the invention and use of banks, book-keeping, exchanges, rechanges, &c.

It does not appear which of the European people, after the settlement of their new masters, first betook themselves to navigation and commerce. Some think it began with the French, although the Italians seem to have the fairest title to this distinction, and are accordingly regarded as the restorers of navigation, as well as of the polite arts, which had been banished together from the time the empire was torn asunder. It is the people of Italy, then, and particularly those of Venice and Genoa, who have the merit of this restoration; and it is to their advantageous situation for navigation that they in great measure owe their glory. In the bottom of the Adriatic were a great number of marshy islands, only separated by narrow channels, but these well screened, and almost inaccessible, the residence of some fishermen, who here supported themselves by a little trade in fish and salt, which they found in some of these islands. Thither the Veneti, a people inhabiting that part of Italy which stretches along the coasts of the gulf, retired, when Alaric, King of the Goths, and afterwards Attila, King of the Huns, ravaged Italy.

These new islanders, little imagining that this was to be their fixed residence, did not think of composing any body politic; but each of the seventy-two islands of this little archipelago continued a long time under its separate master, and each formed a distinct commonwealth. When their commerce had become considerable enough to occasion jealousy to their neighbours, they began to think of uniting into a body; and it was this union, first begun in the sixth century, but not completed till the eighth, that laid the sure foundation of the future grandeur of the state of Venice. From the time of this union, their fleets of merchantmen were sent to all the ports of the Mediterranean; and at last to those of Egypt, particularly Cairo, a new city built by the Saracen princes, on the eastern bank of the Nile, where they traded for the spices and other products of the Indies. Thus they flourished and increased their commerce, their navigation, and their conquests, till the league of Cambray in 1508, when a number of jealous princes conspired to bring about their ruin. This was the more easily effected by the diminution of their East India commerce, of which the Portuguese had got one part and the French another.

Genoa, which had applied itself to navigation at the same time with Venice, and that with equal success, was a long time its dangerous rival, disputed with it the empire of the sea, and shared with it the trade of Egypt and other parts, both of the East and West. But jealousy soon broke out; and the two republics coming to an open rupture, there was almost continual war for three centuries. Towards the end of the fourteenth century, the battle of Chioza ended the strife. The Genoese, who till then had usually the advantage, now lost all; and the Venetians, reduced almost to despair, secured to themselves, by one happy and unexpected blow, the foremost place in commerce and the sole empire of the sea.

About the same time that navigation was retrieved in the southern parts of Europe, a new society of merchants was formed in the north, which not only carried commerce History. to the greatest perfection of which it was capable till the discovery of the East and West Indies, but also formed a new scheme of laws for its regulation, which still obtain under the name of Uses and Customs of the Sea.

This society is that famous league of the Hanse Towns, commonly supposed to have been instituted about the year 1164. (See HANSEATIC LEAGUE, and COMMERCE. For the present state of navigation in the various countries of the world, see under the name of each)

We shall only add, that in examining the causes of commerce passing successively from the Venetians, Genoese, and Hanse Towns, to the Portuguese and Spaniards, and from these again to the English and Dutch, it may be established as a maxim, that the relation between commerce and navigation, or their union, is so intimate, that the fall of the one inevitably draws after it that of the other; and that they will always either flourish or decline together. Hence so many laws, ordinances, statutes, and edicts for its regulation; and hence particularly that celebrated act of navigation, which an eminent foreign author calls the *palladium or tutelar deity of the commerce of England*, which was long considered as the standing rule, not only of the British amongst themselves, but also as that of other nations with whom they trafficked.

The progress of political and commercial science, which gradually opened men's eyes to the great principle that all trade is most healthy and prosperous when subjected to the fewest possible, and those only the most necessary, restrictions, resulted in the total repeal of these famous navigation laws in 1846, since which period trade with England has been free and open to all the world; but so far from British shipping and commerce being injured or diminished, they have been more prosperous since that repeal than they were at any former period, when most carefully fostered by protective laws.

The art of navigation has been exceedingly improved in modern times, both with regard to the form of the vessels themselves, and also with respect to the methods of working them. The use of rowers is now entirely superseded by the improvements made in the formation of the sails, rigging, &c.; by which means ships can not only sail much faster than formerly, but can tack in any direction with the greatest facility; and of late years the extensive and still growing employment of steam as the [illegible] power, whether applied to paddle-wheels or screws, has further placed the mariner beyond the adverse retarding influence of calm and contrary winds, and has introduced an element of certainty and punctuality in commercial intercourse unknown at any previous period, and invaluable as it affects the interests of commerce. It is also very certain that the ancients were neither so well skilled in finding the latitudes, nor in steering their vessels in places of difficult navigation, as the moderns. But the greatest advantage which the moderns possess over the ancients consists in the mariner's compass, by which they are enabled to find their way with more facility in the midst of an immeasurable ocean, than the ancients could have done by creeping along the coast, and never going out of sight of land. Some people indeed contend that this is no new invention, but that the ancients were acquainted with it. They say, that it was impossible for Solomon to have sent ships to Ophir, Tarshish, and Parvaim, which last they imagine to have been Peru, without this useful instrument. They insist, that it was impossible for the ancients to be acquainted with the attractive virtue of the magnet, and to be ignorant of its polarity; nay, they affirm that this property of the magnet is plainly mentioned in the book of Job, where the loadstone is mentioned by the name of *topaz, or the stone that turns itself.* But it is certain that the Romans who conquered Judæa were ignorant of this instrument; and

History. it is very improbable that such a useful invention, if it had once been commonly known to any nation, would have been forgotten, or perfectly concealed from such a prudent people as the Romans, who were so deeply interested in the discovery of it.

Amongst those who admit that the mariner's compass is a modern invention, it has been much disputed who was the inventor. Some attribute the honour of the discovery to Flavio Gioia of Amalfi in Campania, who lived about the beginning of the fourteenth century; whilst others contend that it came from the East, and was earlier known in Europe. But at whatever time it was invented, it is certain that the mariner's compass was not commonly used in navigation before the year 1420. In that year the science was considerably improved under the auspices of Henry, Duke of Visco, brother to the King of Portugal. In the year 1485, Roderick and Joseph, physicians to John II., King of Portugal, together with one Martin de Bohemia, a Portuguese native of the island of Fayal, and scholar of Regiomontanus, calculated tables of the sun's declination for the use of sailors, and recommended the astrolabe for taking observations at sea. Of the instructions of Martin the celebrated Christopher Columbus is said to have availed himself, and to have improved the Spaniards in the knowledge of the art; for the farther progress of which a lecture was afterwards founded at Seville by the Emperor Charles V.

The discovery of the variation is claimed both by Columbus and by Sebastian Cabot. The former certainly did observe the variation, without having heard of it from any other person, on the 14th of September 1492, and it is very probable that Cabot might have done the same. At that time it was found that there was no variation at the Azores, where some geographers have thought proper to place the first meridian, though it has since been observed that the variation alters in time. The use of the cross staff now began to be introduced amongst sailors. This ancient instrument is described by John Werner of Nuremberg, in his annotations on the first book of Ptolemy's *Geography*, printed in the year 1514. He recommends it for observing the distance between the moon and some star, in order thence to determine the longitude.

At this time the art of navigation was very imperfect, on account of the inaccuracies of the plane chart, which was the only one then known, and which, by its gross errors, must have greatly misled the mariner, especially in voyages far distant from the equator. Its precepts were probably at first only set down on the sea-charts, as is the custom at this day; but at length two Spanish treatises were published in the year 1545,—one by Pedro de Medina, and the other by Martin Cortes,—which contained a complete system of the art, as far as it was then known. These seem to have been the oldest writers who fully handled the art; for Medina, in his dedication to Philip, Prince of Spain, laments that multitudes of ships daily perished at sea, because there were neither teachers of the art, nor books by which it might be learned; and Cortes, in his dedication, boasts to the emperor that he was the first who had reduced navigation into a compendium, valuing himself much on what he had performed. Medina defended the plane chart; but he was opposed by Cortes, who showed its errors, and endeavoured to account for the variation of the compass by supposing the needle to be influenced by a magnetic pole (which he called the *point attractive*), different from that of the world, which notion has been farther prosecuted by others, and is now generally accepted as true in the scientific world. Medina's book was soon translated into Italian, French, and Flemish, and for a long time served as a guide to foreign navigators. Cortes, however, was the favourite author of the English nation, and was translated in the year 1561; whilst Medina's work was entirely neglected, though translated also within a short time of the other. At that time the system of navigation consisted of an account of the Ptolemaic hypothesis, and the circles of the sphere; of the roundness of the earth, the longitudes, latitudes, climates, &c., and eclipses of the luminaries; a calendar; the method of finding the prime, epact, moon's age, and tides; a description of the compass, an account of its variation, for the discovery of which Cortes said that an instrument might easily be contrived; tables of the sun's declination for four years, in order to find the latitude from his meridian altitude; directions to find the same by certain stars; of the course of the sun and moon; the length of the days; of time and its divisions; the method of finding the hour of the day and night; and, lastly, a description of the sea chart, on which, in order to discover where the ship was, they made use of a small table, which showed, upon an alteration of one degree of the latitude, how many leagues were run in each rhumb, together with the departure from the meridian. Some other instruments were also described, especially by Cortes; such as one to find the place and declination of the sun, with the days and place of the moon; certain dials, the astrolabe, and cross staff; together with a complex machine to discover the hour and latitude at once. History.

About the same time proposals were made for finding the longitude by observations of the moon. In 1530 Gemma Frisius advised the keeping of time by means of small clocks or watches, which were then, as he says, newly invented. He also contrived a new sort of cross-staff, and an instrument called the *nautical quadrant*, which last was much praised by William Cunningham in his *Astronomical Glass*, printed in the year 1559.

In the year 1537, Pedro Nunez, or Nonius, published a book in the Portuguese language, to explain a difficulty in navigation proposed to him by the commander Don Martin Alphonso de Susa. In this he exposed the errors of the plane chart, and likewise gave the solution of several curious astronomical problems, amongst which was that of determining the latitude from two observations of the sun's altitude and the intermediate azimuth. He observed, that although the rhumbs are spiral lines, yet the direct course of a ship will always be in the arc of a great circle, whereby the angle with the meridians will continually change; and hence all that the steersman can here do for the preserving of the original rhumb, is to correct these deviations as soon as they appear sensible. But in reality the ship will thus describe a course without the rhumb line intended; and therefore his calculations for assigning the latitude, where any rhumb line crosses the several meridians, will be in some measure erroneous. He invented a method of dividing a quadrant by means of concentric circles, which, after having been much improved by Dr Halley, is used at present, and is called a *nonius*.

In the year 1577, William Bourne published a treatise in which, by considering the irregularities in the moon's motion, he showed the error of the sailors in finding her age by the epact, and also in determining the hour from observing on what point of the compass the sun and moon appeared. He advised, in sailing towards high latitudes, to keep the reckoning by the globe, as there the plane chart was most erroneous. He despaired of our ever being able to find the longitude, unless the variation of the compass should be occasioned by some such attractive point as Cortes had imagined, of which, however, he doubted; but as he had shown how to find the variation at all times, he recommended to keep an account of the observations, as useful for finding the place of the ship; and this advice was prosecuted at large by Simon Stevin, in a treatise published at Leyden in 1599, the substance of which was the same year printed at London in English by Edward Wright,

History. entitled the *Haven-finding Art*. In this ancient tract is also described the method by which our sailors estimate the rate of a ship in her course, by an instrument called the *log*. This was so named from the piece of wood or log which floats in the water, whilst the time is reckoned during which the line that is fastened to it is veering out. The inventor of this contrivance is not known; but it was first described in an account of an East India voyage published by Purchas in 1607, from which time it became famous, and was much taken notice of by almost all writers on navigation in every country. It still continues to be used as at first, although many attempts have been made to improve it, and contrivances proposed to supply its place, many of which have succeeded in quiet water, but proved useless in a stormy sea.

In the year 1581 Michael Coignet, a native of Antwerp, published a treatise, in which he animadverted on Medina. In this he showed, that as the rhumbs are spirals, making endless revolutions about the poles, numerous errors must arise from their being represented by straight lines on the sea charts; but although he hoped to find a remedy for these errors, he was of opinion that the proposals of Nonius were scarcely practicable, and therefore in a great measure useless. In treating of the sun's declination, he took notice of the gradual decrease in the obliquity of the ecliptic; he also described the cross staff with three transverse pieces, which he admitted were then in common use amongst the sailors. He likewise described some instruments of his own invention; but all of them are now laid aside, excepting perhaps his nocturnal. He constructed a sea table to be used by such as sailed beyond the sixtieth degree of latitude; and at the end of the book is delivered a method of sailing upon a parallel of latitude by means of a ring dial and a twenty-four hour glass. The same year the discovery of the dipping-needle was made by Robert Norman. In his publication on that subject he maintains, in opposition to Cortes, that the variation of the compass was caused by some point on the surface of the earth, and not in the heavens; and he also made considerable improvements on the construction of compasses themselves, showing especially the danger of not fixing, on account of the variation, the wire directly under the *fleur de lis*, as compasses made in different countries have it placed differently. To this performance of Norman's is prefixed a discourse on the variation of the magnetical needle, by William Burrough, in which he shows how to determine the variation in many different ways, and also points out many errors in the practice of navigation at that time, speaking in very severe terms concerning those who had published upon it.

During this time the Spaniards continued to publish treatises on the art. In 1585 an excellent *Compendium* was published by Roderico Zamorano, and contributed greatly towards the improvement of the art, particularly in the sea charts. Globes of an improved kind, and of a much larger size than those formerly used, were now constructed, and many improvements were made in other instruments; nevertheless, the plane chart continued still to be followed, though its errors were frequently complained of. Methods of removing these errors had indeed been sought after; and Gerard Mercator seems to have been the first who found the true method of effecting this, so as to answer the purposes of seamen. He represented the degrees both of latitude and longitude by parallel straight lines, but gradually augmented the space between the former as they approached the pole. Thus the rhumbs, which otherwise ought to have been curves, were now also extended into straight lines; and thus a straight line drawn between any two places marked upon the chart formed an angle with the meridians, expressing the rhumb leading from the one to the other. But although in 1569 Mercator published a universal map constructed in this manner, it does not appear that he was acquainted with the principles upon which this proceeded; History. and it is now generally believed, that the true principles on which the construction of what is called *Mercator's Chart* depends, were first discovered by Edward Wright, an Englishman.

Wright supposed, but, according to the general opinion, without sufficient grounds, that this enlargement of the degrees of latitude was known and mentioned by Ptolemy, and that the same thing had also been spoken of by Cortes. The expressions of Ptolemy alluded to relate, indeed, to the proportion between the distances of the parallels and meridians; but instead of proposing any gradual widening between the parallels of latitude in a general chart, he speaks only of particular maps, and advises not to confine a system of such maps to one and the same scale, but to plan them out by a different measure, as occasion might require; with this precaution, however, that the degrees of longitude in each should bear some proportion to those of latitude, and this proportion was to be deduced from that which the magnitude of the respective parallels bore to a great circle of the sphere. He added, that, in particular maps, if this proportion be observed with regard to the middle parallel, the inconvenience will not be great, although the meridians should be straight lines parallel to each other. But here he is understood only to mean, that the maps should in some measure represent the figures of the countries for which they are drawn. In this sense Mercator, who drew maps for Ptolemy's tables, understood him; thinking it, however, an improvement not to regulate the meridians by one parallel, but by two, one distant from the northern, the other from the southern extremity of the map, by a fourth part of the whole depth; by which means, in his maps, although the meridians are straight lines, yet they are generally drawn inclining to each other towards the poles. With regard to Cortes, he speaks only of the number of degrees of latitude, and not of the extent of them; nay, he gives express directions that they should all be laid down by equal measurement in a scale of leagues adapted to the map.

For some time after the appearance of Mercator's map it was not rightly understood, and it was even thought to be entirely useless, if not detrimental. However, about the year 1592 its utility began to be perceived; and seven years afterwards Wright printed his famous treatise entitled *The Correction of certain Errors in Navigation*, where he fully explained the reason of extending the length of the parallels of latitude, and the use thereof to navigators. In 1610 a second edition of Wright's book was published, with improvements. An excellent method was proposed of determining the magnitude of the earth; and at the same time it was judiciously proposed to make our common measures in some proportion to a degree on its surface, that they might not depend on the uncertain length of a barleycorn. Amongst his other improvements may be mentioned the Table of Latitudes for Dividing the Meridian computed to Minutes, whereas it had been only divided to every tenth minute. He also published a description of an instrument which he calls the *sea rings*, by which the variation of the compass, the altitude of the sun, and the time of the day, may at once readily be determined in any place, provided the latitude is known. He also showed how to correct the errors arising from the eccentricity of the eye in observing by the cross staff. In the years 1593, 1594, 1596, and 1597, he amended the tables of the declination and places of the sun and stars from his own observations made with a six-feet quadrant, a sea quadrant to take altitudes by a forward or backward observation, and likewise with a contrivance for the ready finding of the latitude by the height of the pole-star, when not upon the meridian. To this edition was subjoined a translation of Zamorano's *Compendium*, above mentioned, in which he corrected some

History. mistakes in the original, adding a large table of the variation of the compass observed in different parts of the world, in order to show that it was not occasioned by any magnetical pole.

These improvements soon became known abroad. In 1608 a treatise, entitled *Hypomnemata Mathematica*, was published by Simon Stevin for the use of Prince Maurice. In the portion of the work relating to navigation, the author treated of sailing on a great circle, and showed how to draw the rhumbs on a globe mechanically; he also set down Wright's two tables of latitudes and of rhumbs, in order to describe these lines more accurately; and even pretended to have discovered an error in Wright's table. But Stevin's objections were fully answered by the author himself, who showed that they arose from the rude method of calculating made use of by the former.

In 1624 the learned Willebrordus Snellius, professor of mathematics at Leyden, published a treatise of navigation on Wright's plan, but somewhat obscurely; and as he did not particularly mention all the discoveries of Wright, the latter was thought by some to have taken the hint of all his discoveries from Snellius. But this supposition has been long ago refuted; and Wright's title to the honour of those discoveries remains unchallenged.

Having shown how to find the place of the ship upon his chart, Wright observed that the same might be performed more accurately by calculation; but considering, as he says, that the latitudes, and especially the courses at sea, could not be determined so precisely, he forbore setting down particular examples; as the mariner may be allowed to save himself this trouble, and only to mark out upon his chart the ship's way, after the manner then usually practised. However, in 1614, Raphe Handson, amongst the nautical questions which he subjoined to a translation of Pitiscus's *Trigonometry*, solved very distinctly every case of navigation, by applying arithmetical calculations to Wright's *Tables of Latitudes*, or of Meridional Parts, as it has since been called. Although the method discovered by Wright for finding the change of longitude by a ship sailing on a rhumb is the proper way of performing it, Handson also proposes two methods of approximation without the assistance of Wright's division of the meridian line. The first was computed by the arithmetical mean between the cosines of both latitudes; and the other by the same mean between the secants, as an alternative when Wright's book was not at hand; although this latter is wider of the truth than the former. By the same calculations also he showed how much each of these compends deviates from the truth, and also how widely the computations on the erroneous principles of the plane chart differ from them all. The method generally used by our sailors, however, is commonly called the *middle latitude*, which, although it errs more than that by the arithmetical mean between the two cosines, is preferred on account of its being less operose; yet in high latitudes it is more eligible to use that of the arithmetical mean between the logarithmic cosines, equivalent to the geometrical mean between the cosines themselves—a method since proposed by John Bassat. The computation by the middle latitude will always fall short of the true change of longitude, that by the geometrical mean will always exceed; but that by the arithmetical mean falls short in latitudes of about 45°, and exceeds in lesser latitudes. However, none of these methods will differ much from the truth when the change of latitude is sufficiently small.

About this period logarithms were invented by John Napier, Baron of Merchiston in Scotland, and proved of the utmost service to the art of navigation. From these Edmund Gunter constructed a table of logarithmic sines and tangents to every minute of the quadrant, which he published in 1620. In this work he applied to navigation, and other branches of mathematics, his admirable ruler known by the name of Gunter's Scale,[1] on which are described lines of logarithms, of logarithmic sines and tangents, of meridional parts, &c.; and he greatly improved the sector for the same purposes. He also showed how to take a back observation by the cross staff, by which the error arising from the eccentricity of the eye is avoided. He likewise described another instrument, of his own invention, called the *cross bow*, for taking altitudes of the sun or stars, with some contrivances for more readily finding the latitude from the observation. The discoveries concerning logarithms were carried into France in 1624 by Edmund Wingate, who published two small tracts in that year at Paris. In one of these he taught the use of Gunter's scale; and in the other, that of the tables of artificial sines and tangents, as modelled according to Napier's last form, erroneously attributed by Wingate to Briggs. History.

Gunter's scale was projected into a circular arch by the Reverend William Oughtred in 1633; and its uses were fully shown in a pamphlet entitled the *Circles of Proportion*, where, in an appendix, several important points in navigation are well treated. It has also been made in the form of a sliding ruler.

The logarithmic tables were first applied to the different cases of sailing, by Thomas Addison, in his treatise entitled *Arithmetical Navigation*, printed in the year 1625. He also gave two traverse tables, with their uses; the one to quarter points of the compass, and the other to degrees. Henry Gellibrand published his discovery of the changes of the variation of the compass, in a small quarto pamphlet, entitled *A Discourse Mathematical on the Variation of the Magnetical Needle*, printed in 1635. This extraordinary phenomenon he found out by comparing the observations which had been made at different times near the same place by Burrough, Gunter, and himself, all persons of great skill and experience in these matters. This discovery was likewise soon known abroad; for Athanasius Kircher, in his treatise entitled *Magnes*, first printed at Rome in the year 1641, informs us that he had been told of it by John Greaves, and then gives a letter of the famous Marinus Mersennus, containing a very distinct account of the same.

As altitudes of the sun are taken on shipboard by observing his elevation above the visible horizon, to obtain from these the sun's true altitude with correctness, Wright observed it to be necessary that the dip of the visible horizon below the horizontal plane passing through the observer's eye should be brought into the account, which cannot be calculated without knowing the magnitude of the earth. Hence he was induced to propose different methods for finding this; but he complains that the most effectual was out of his power to execute, and therefore he contented himself with a rude attempt, in some measure sufficient for his purpose. The dimensions of the earth deduced by him corresponded very well with the usual divisions of the log-line; nevertheless, as he did not write an express treatise on navigation, but only for correcting such errors as prevailed in general practice, the log-line did not fall under his notice. Richard Norwood, however, put in execution the method recommended by Wright as the most perfect for measuring the dimensions of the earth, with the true length of the degrees of a great circle upon it; and in 1635 he actually measured the distance between London and York; from which measurement, and the summer solstitial altitudes of the sun observed on the meridian at both places, he found a degree on a great circle of the earth to contain 367,196 English feet, equal to 57,300 French

[1] See Gunter's Scale.

History. fathoms or toises; which is very exact, as appears from many measurements that have been made since that time. Of all this Norwood gave a full account in his treatise called the *Seaman's Practice*, published in 1657. He there showed the reason why Snellius had failed in his attempt; and he also pointed out various uses of his discovery, particularly for correcting the gross errors hitherto committed in the divisions of the log-line. But necessary amendments have been little attended to by sailors, whose obstinacy in adhering to established errors has been complained of by the best writers on navigation. This improvement, however, has at length made its way into practice; and few navigators of reputation now make use of the old measure of forty-two feet to a knot. In this treatise Norwood also describes his own excellent method of setting down and perfecting a sea reckoning, by using a traverse table, which method he had followed and taught for many years. He likewise shows how to rectify the course, by taking into consideration the variation of the compass; as also how to discover currents, and to make proper allowance on their account. This treatise, and another on Trigonometry, were continually reprinted, as the principal books for learning scientifically the art of navigation. What he had delivered, especially in the latter of them, concerning this subject, was abridged as a manual for sailors, in a very small work called an *Epitome;* which useful performance has gone through a great number of editions. No alterations were ever made in the *Seaman's Practice* till the twelfth edition in 1676, when the following paragraph was inserted in a smaller character:—"About the year 1672, Monsieur Picart has published an account in French concerning the measure of the earth, a breviate whereof may be seen in the *Philosophical Transactions*, No. 112, wherein he concludes one degree to contain 365,184 English feet, nearly agreeing with Mr Norwood's experiment;" and this advertisement is continued through the subsequent editions as late as the year 1732.

About the year 1645, Bond published, in Norwood's *Epitome*, a very great improvement of Wright's method, from a property in his meridian line, whereby the divisions are more scientifically assigned than the author himself was able to effect. It resulted from this theorem, that these divisions are analogous to the excesses of the logarithmic tangents of half the respective latitudes augmented by 45° above the logarithm of the radius. This he afterwards explained more fully in the third edition of Gunter's works, printed in 1653, where he observed that the logarithmic tangents from 45° upwards increase in the same manner as the secants do added together, if every half degree be accounted as a whole degree of Mercator's meridional line. His rule for computing the meridional parts belonging to any two latitudes, supposed to be on the same side of the equator, is to the following effect:—"Take the logarithmic tangent, rejecting the radius, of half each latitude, augmented by 45°; divide the difference of those numbers by the logarithmic tangent of 45° 30′, the radius being likewise rejected, and the quotient will be the meridional parts required, expressed in degrees." This rule is the immediate consequence of the general theorem, that the degrees of latitude bear to one degree (or sixty minutes, which in Wright's table stand for the meridional parts of one degree) the same proportion as the logarithmic tangent of half any latitude augmented by 45°, and the radius neglected, to the like tangent of half a degree augmented by 45°, with the radius likewise rejected. But here there was still wanting the demonstration of this general theorem, which was at length supplied by James Gregory of Aberdeen, in his *Exercitationes Geometricæ*, printed at London in 1668; and afterwards more concisely demonstrated, together with a scientific determination of the divisor, by Dr Halley, in the *Philosophical Transactions* for 1695 (No. 219), from the consideration of the spirals into which the rhumbs are transformed in the stereographic projection of the sphere upon the plane of the equinoctial, and which is rendered still more simple by Roger Cotes, in his *Logometria*, first published in the *Philosophical Transactions* for 1714 (No. 388). It is, moreover, added in Gunter's book, that if $\frac{1}{3}$th of this division, which does not sensibly differ from the logarithmic tangent of 45° 1′ 30″, with the radius subtracted from it, be used, the quotient will exhibit the meridional parts expressed in leagues; and this is the divisor set down in Norwood's *Epitome*. After the same manner, the meridional parts will be found in minutes, if the like logarithmic tangent of 45° 1′ 30″, diminished by the radius, be taken; that is, the number used by others being 12633, when the logarithmic tables consist of eight places of figures besides the index. History.

In an edition of a book called the *Seaman's Kalendar*, Bond declared that he had discovered the longitude by having found out the true theory of the magnetic variation; and to gain credit to his assertion, he foretold, that at London in 1657 there would be no variation of the compass, and from that time it would gradually increase the other way; which happened accordingly. Again, in the *Philosophical Transactions* for 1668 (No. 40), he published a table of the variation for forty-nine years to come. Thus he acquired such reputation, that his treatise entitled *The Longitude Found*, was, in the year 1676, published by the special command of Charles II., and approved by many celebrated mathematicians. It was not long, however, before it met with opposition; and in the year 1678 another treatise, entitled *The Longitude not Found*, made its appearance; and as Bond's hypothesis did not answer its author's sanguine expectations, the solution of the difficulty was undertaken by Dr Halley. The result of his speculation was, that the magnetic needle is influenced by four poles; but this wonderful phenomenon seems hitherto to have eluded all our researches. (See Magnetism.) In 1700, however, Dr Halley published a general map, with curve lines expressing the paths where the magnetic needle had the same variation; which was received with universal applause. But as the positions of these curves vary from time to time, they should frequently be corrected by skilful persons, as was done in 1744 and 1756, by Mountain and Dodson. In the *Philosophical Transactions* for 1690, Dr Halley also gave a dissertation on the monsoons, containing many very useful observations for such as sail to places subject to these winds.

After the true principles of the art were settled by Wright, Bond, and Norwood, new improvements were daily made, and everything relative to it was settled with an accuracy not only unknown to former ages, but which would have been reckoned utterly impossible. The earth being found to be, not a perfect sphere, but a spheroid, with the shortest diameter passing through the poles, a tract was published in 1741 by the Reverend Dr Patrick Murdoch, wherein he accommodated Wright's sailing to such a figure; and the same year Colin Maclaurin, in the *Philosophical Transactions* (No. 461), gave a rule for determining the meridional parts of a spheroid; which speculation is farther treated of in his book of Fluxions, printed at Edinburgh in 1742, and in Delambre's *Astronomy* (t. iii., ch. xxxvi.).

Amongst the later discoveries in navigation, that of finding the longitude, both by lunar observations and by time-keepers, is the principal. It is owing chiefly to the rewards offered by the British Parliament that this has attained the present degree of perfection. We are indebted to Dr Maskelyne for putting the first of these methods in practice, and for other important improvements in navigation. The time-keepers constructed by Harrison for this express

Practice of Navigation.

purpose were found to answer so well that he obtained the parliamentary reward. These have been improved by Arnold, Earnshaw, and many others, so as now to be almost in common use.

The works which have latterly appeared on navigation are those on the longitude and navigation by Mackay, Inman, Riddle, Norie, Jeans, and others; and these contain every necessary requisite to form the practical navigator.

Preliminary Principles.

PRACTICE OF NAVIGATION.

BOOK I.

CONTAINING THE VARIOUS METHODS OF SAILING.

The art of navigation depends upon mathematical and astronomical principles. The problems in the various modes of sailing are resolved either by trigonometrical calculations, or by tables or rules formed by the assistance of plane and spherical trigonometry. By mathematics the necessary tables are constructed and rules investigated for performing the more difficult parts of navigation.

The places of the sun, moon, and planets, and fixed stars, are deduced from observation and calculation, and arranged in tables, the use of which is absolutely necessary in reducing observations taken at sea for the purpose of ascertaining the latitude and longitude of the ship and the variation of the compass. The investigation of the rules required for this purpose belongs properly to the science of ASTRONOMY, to which the reader is referred. A few tables are given at the end of this article, but as the other tables necessary for the practice of navigation are to be found in almost every treatise on this subject, it seems unnecessary to insert them in this place. The subject naturally divides itself under two heads:—*First*, The methods of conducting a ship from one port to another by help of rules, in which the log-line and compass are alone required, which is *Navigation* properly so called. *Second*, The method of ascertaining the ship's latitude and longitude, and variation of compass, by means of observations on the heavenly bodies; and the rules for that purpose deduced from astronomy, in order to correct the ship's place, and the courses derived from the former method, to which the name of *Nautical Astronomy* is generally applied. Although the reader is referred to the respective articles on the sciences on which navigation is founded in this work for complete information, we shall, nevertheless, endeavour to make our explanation of the several rules as complete as possible, even at the risk of repeating somewhat the substance of portions of our other articles.

CHAP. I.—PRELIMINARY PRINCIPLES.

SECT I.—ON LATITUDE AND LONGITUDE; DEFINITION OF TERMS USED IN NAVIGATION; AND GENERAL EXPLANATIONS.

1. *Latitude and Longitude.*

The situation of a place, or any object on the earth's surface, is estimated by its distance from two imaginary lines on that surface intersecting each other at right angles. The one of these is called the *Equator*, and the other the *First Meridian*. The situation of the equator is fixed; but that of the first meridian is arbitrary, and therefore different nations assume different first meridians. In Great Britain we assume that to be the first meridian which passes through the Royal Observatory at Greenwich.

The equator is a great circle on the earth's surface, every point of which is equally distant from the two poles or the extremities of the imaginary axis about which the earth makes her diurnal rotation. It therefore divides the earth into two equal parts, called the *Northern* and the *Southern Hemispheres*, according as the *North* or the *South Pole* lies within them.

The latitude of a place is its distance from the equator, reckoned on a meridian in degrees, minutes, and seconds, and decimal parts of seconds (if necessary), being either north or south, according as it is the Northern or Southern Hemisphere. Hence it appears that the latitudes of all places are comprised within the limits 0° and 90° N., and 0° and 90° S.

The first meridian, which is a great circle passing through the poles, also divides the earth into two equal portions, called the *Eastern* and *Western Hemispheres*, according as they lie to the *right* or *left* of the first meridian; the spectator being supposed to be looking towards the *north*.

The longitude of a place is the arc of the equator intercepted between the first meridian and the meridian of the given place reckoned in degrees, minutes, and seconds; and is either east or west as the place lies in the Eastern or Western Hemisphere respectively to the first meridian. The longitude of all places on the earth's surface is comprised within the limits of 0° and 180° E., and 0° and 180° W.

On the supposition that the earth is a sphere, the length of all arcs of great circles upon it subtending an angle of 1° at the centre are equal; hence 1′ of latitude or longitude is equal to one geographical or nautical mile, of which a degree contains 60. Hence intervals of latitude and longitude, reduced to minutes and parts of minutes, also represent the same number of nautical miles and parts of a nautical mile.

In the practice of navigation, the latitude and longitude of the place which a ship leaves, are called the latitude and longitude *from*; and the latitude and longitude of the place at which it has arrived, are called the latitude and longitude *in*.

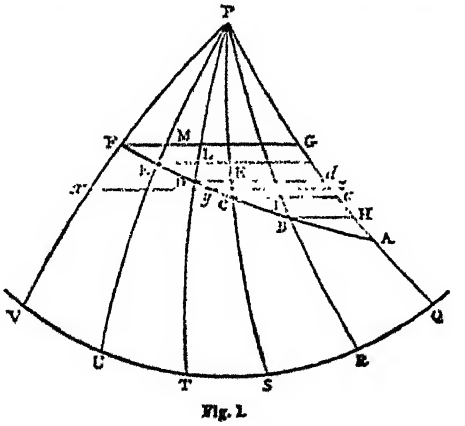

Fig. 1.

2. *Definitions of Terms used in Navigation, and Explanations.*

Let QR...V be a portion of the equator, P the pole, and PAQ, PBR, PCS.....PFV be meridians supposed very near to one another, passing through points A, B, C, D, E, F, the line AF being the path traced out by a vessel in passing from A to F, such that it makes equal angles with every meridian over which it passes. From B, C, D, &c., let BH, CI, DK, EL, &c., be drawn perpendicular to the

Preliminary Principles.

two meridians between which they respectively lie; or, in other words, be arcs of small circles or parallels of latitude through the points B, C, &c. These are consequently all parallel to one another, and to FG the whole arc of the parallel at F included between the extreme meridians PAQ and PFV.

The constant angle at which the line AF is inclined to the successive meridians, viz., BAP, CBP, DCP, &c., is called the *course*. Also, if the small circles or parallels at B, C, &c., be continued to the meridian PAQ, the portion of this meridian intercepted between any two consecutive parallels, as *cd*, will be equal to CK, the distance between the parallels through C and D; and so on for all. Hence the sum of these distances, AH + BI + CK + DL + EM = AG; which is called the *true difference of latitude*, or true diff. lat. from A to F.

The corresponding arcs of parallels at different latitudes intercepted between the same meridians are not equal, but gradually decrease from the equator to the poles. Hence the sum of the arcs BH + CI + DK + EL + FM is less than QV, the intercepted arc of the equator, but greater than FG, the arc of the highest parallel intercepted between PAQ and PFV.

BH + CI + DK + EL + FM is called the *departure*; the arc QV of the equator is the *difference of longitude*; and AF, the curve described by the vessel in passing from A to F, is called the *distance*.

In navigation, each of the triangles ABH, BCI, &c., is considered as a plane triangle; and as each of them is right-angled, and contains, besides, one constant angle, viz., the course, the other angle in each must also be constant; and all the triangles will be equiangular and similar. Hence we have

$$\begin{array}{l} AH : BH :: AB :: AH : BH : AB \\ BI : CI :: BC :: AH : BH : AB \\ CK : DK : CD :: AH : BH : AB \\ \quad \&c. \quad\quad \&c. \quad\quad \&c. \\ EM : FM : EF :: AH : BH : AB. \end{array}$$

And since, when any number of quantities are in continued proportion, as the first consequent is to its antecedent, so are all the consequents to all the antecedents; we have

$$AH + BI + CK + \&c. : BH + CI + DK + \&c. : AB + BC + CD + \&c. :: AH : BH : AB.$$

But AH + BI + CK + &c. = AG the true diff. lat.
BH + CI + DK + &c. = the departure.
AB + BC + CD + &c. = AF or the distance.

Hence the true difference of latitude, departure, and distance, may be considered as the sides of a right-angled triangle, similar to each of the small triangles; the angle of which, therefore, between the true difference of latitude and distance, is the course.

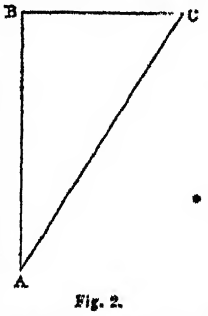

Fig. 2.

Take AB (fig. 2) = the true diff. lat. Draw BC at right angles to it = departure. Join AC. Then AC is the *distance*, and BAC is the *course*.

From this it appears, that when any two of the four quantities, true difference of latitude, departure, distance, and course are given, the remaining two can be found by solving the right-angled triangle ABC.

1. Given course (BAC) and distance (AC), to find true difference of latitude (AB), and departure (BC).

$$AB = AC \cos BAC$$
$$BC = AC \sin BAC,$$

i.e., true diff. lat. (in miles) = dist. × cos course . (I.)
and departure = dist. × sin course . (II.)

Or in logarithms,

log. true diff. lat. = log. dist. + L. cos course − 10,

where L means tabular logarithm, *i.e.*, logarithm increased by 10; and log. dep. = log. dist. + L. sin course − 10.

Preliminary Principles.

2. Given course (BAC) and true difference of latitude (AB), to find distance and departure.

$$AC = AB \times \sec BAC$$
$$BC = AB \times \tan BAC;$$

or dist. = true diff. lat. × sec course . . . . (III.)
dep. = true diff. lat. × tan course . . . . (IV.)

3. Given course and departure, to find distance and true difference of latitude.

$$AC = BC \times \operatorname{cosec} BAC$$
$$AB = BC \times \cot BAC;$$

or dist. = dep. × cosec course . . . (V.)
and true diff. lat. = dep. × cot course . . . . (VI.)

4. Given distance and true difference of latitude, to find course and departure.

$$\cos BAC = \frac{AB}{AC};$$

or cosine course = true diff. lat. ÷ dist. (VII.)

And the course having been found, we get

dep. = dist. × sin course by (II.)

5. Given the distance and departure, to find the course and true difference of latitude.

$$\sin BAC = \frac{BC}{AC};$$

or sin course = dep. ÷ distance . (VIII.)

And then we have

true diff. lat. = dist. × cos course.

6. Given the true difference of latitude and departure, to find the course and distance.

$$\tan BAC = \frac{BC}{AB};$$

or tan course = dep. ÷ true diff. lat. . . (IX.)

And having found the course, we have

dist. = true diff. lat. × sec course by (III.);
or dist. = dep. × cosec course by (V.)

Length of Arc of 1° of Parallels of Latitude.

We have already stated that the lengths of the parallels of latitude diminish as the latitude increases. In fact, it decreases in the ratio of cosine latitude to unity.

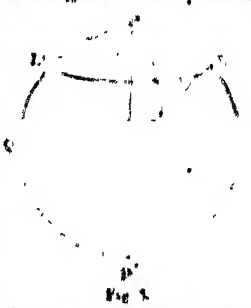

Fig. 3.

Let EQ be the equator, PCP' the polar diameter of the earth passing through C, and LML' any parallel of latitude. Let the angle ECL, or the latitude, be *l*, and let LM and EF be the arcs of the parallel and of the equator intercepted between the meridians PEP' and PFP'. Then angle ECF = angle LOM, because they both measure the angle between the planes of the two meridians. Hence

arc LM : arc EF :: OL : CE :: OL : CL, because CE = CL;

$$\text{or arc LM} = \text{arc EF} \times \frac{OL}{CL} = \text{arc EF} \times \sin OCL$$
$$= \text{arc EF} \times \cos LCE = \text{arc EF} \times \cos l.$$

Hence if FE be the length of an arc 1° of longitude at the equator, or 60 miles, LM the length of an arc 1° of longitude in latitude *l* = 60 × cos *l*.

Preliminary principles.

Middle Latitude.

The departure is less than VQ (fig. 1), the intercepted arc of the equator, or than the intercepted arc of the parallel through A; but it is greater than FG. But since the arc of the parallel gradually decreases from A to F, there is some point intermediate in position between A and F (y), the intercepted arc of the parallel of which will be exactly equal to the departure. The exact determination of this point is not very easy. Various methods have been proposed to determine this latitude nearly, with as little trouble as possible: first, by taking the arithmetical mean of the two latitudes for that of the mean latitude; secondly, by using the arithmetical mean of the cosines of the latitudes; thirdly, by using the geometrical mean of these cosines; and, lastly, by employing the latitude deduced from the mean of the meridional parts of the two latitudes. The first of these methods is the one usually employed. It has the merit of great simplicity; and as all the rules in navigation are approximate only, it may perhaps be depended on as much as any of these. Hence y may be considered as the middle point between A and F; and dep. $= xyz$.

But $xyz = \text{VQ} \cos \text{lat. of } y$;

or dep. = diff. long. $\times \cos y$, where y is the arithmetical mean of the latitudes of A and F $= \frac{1}{2}(l+l')$, if

l = latitude of A,

l' = latitude of F.

This is commonly called the *middle latitude*. Hence we have

dep. = diff. long. $\times$ cos middle latitude.

By equation (1.) we have

true diff. lat. = dist. $\times$ cos course.

Whence it appears that if the middle latitude be considered as a course, and the departure as a true difference of latitude, the corresponding distance will be the difference of longitude. And conversely, treating the middle latitude as a course, and the difference of longitude as a distance, the corresponding true difference of latitude will be the departure.

Mercator's Chart—Meridional Parts.

The chart used at sea for tracing the ship's track exhibits the surface of the earth on a plane, in which the meridians are parallel, and consequently the distance between them throughout their length equal to the equatorial distance, instead of gradually decreasing as the latitude increases. In other words, FG is increased so as to become equal to VQ. Now, in order that on this chart all points may occupy the same relative position with respect to each other that the points corresponding to them do on the surface of the globe, the distance AF and the distance AG must be increased in the same proportion that BH + CI + DK + &c., *i.e.*, the departure has been increased.

The distance AG so increased is called the *meridional difference of latitude*, or mer. diff. lat.; and the chart constructed on this principle is called Mercator's Chart. If for any latitude the meridional difference of latitude between this point and the equator be expressed in miles or minutes, the number of miles so expressed is called the *meridional parts* for that latitude. A table of meridional parts for every minute of latitude from 0° up to 90°, is given in every collection of nautical tables.

Construction of Table of Meridional Parts.

This table may be constructed approximately, by dividing the whole meridian from 0° to 90° into intervals of 1′, and supposing the increase of the arc of the parallel of latitude, and consequently that of the arc of latitude, to take place at the end of the successive minutes.

Now we have seen that an arc of any parallel = corresponding arc of equator $\times$ cos lat.; and since the arcs of the successive parallels have all become equal to the corresponding arc of the equator, they have all been increased in the ratio of sec lat. to 1.

Hence, if the length of 1′ of the meridian be 1, and a, b, c, d, the corresponding increased lengths between 0 and 1′, between 1′ and 2′, 2′ and 3′, &c.,

$$a = 1 \times \sec 1'$$
$$b = 1 \times \sec 2'$$
$$c = 1 \times \sec 3$$
$$d = 1 \times \sec 3$$
$$\&c. \quad \&c.$$

And $a+b+c$, &c. $= \sec 1' + \sec 2' + \sec 3' + \&c.$; or the meridional parts in any arc of the meridian is equal to the sum of the secants of all the successive angles, differing by 1′, from 1′ up to the given latitude.

The true investigation is as follows:—Let m = the circular measure of the angle subtended at the centre by the meridional parts in the arc between the latitudes 0 and l; and let l become $l+\delta l$, and let δm be the corresponding increase of m. Then δm is proportional to the secant of $l+\delta l$;

$$\text{or } \frac{\delta m}{\delta l} = \sec (l+\delta l).$$

And ultimately taking the limit

$$\frac{dm}{dl} = \sec l;$$

$$\therefore m = \int_0^l \sec l\, dl = \int_0^l \frac{1}{\cos l}\, dl$$

$$= \int_0^l \frac{\cos^2 \frac{l}{2} - \sin^2 \frac{l}{2}}{\cos^2 \frac{l}{2} - \sin^2 \frac{l}{2}}\, dl = \int_0^l \frac{\left(1+\tan^2 \frac{l}{2}\right) dl}{1-\tan^2 \frac{l}{2}}$$

$$= 2\int_0^l \frac{d \cdot \tan \frac{l}{2}}{1-\tan^2 \frac{l}{2}} = \log. \frac{1+\tan \frac{l}{2}}{1-\tan \frac{l}{2}}$$

$$= \log. \left(\frac{\cos\left(45 - \frac{l}{2}\right)}{\cos 45 + \frac{l}{2}} \right).$$

Let $45 - \frac{l}{2} = \frac{l_1}{2}$, or $90 - l = l_1$;

$$45 + \frac{l}{2} = 90 - \frac{l_1}{2};$$

$$\text{and } m = \log. \frac{\cos \frac{l_1}{2}}{\sin \frac{l_1}{2}} - \log. \cot \frac{l_1}{2}$$

$$= 2{\cdot}3025851 \log_{10} \cot \tfrac{1}{2} l_1.$$

$$\text{Now } m = \frac{\text{arc}}{\text{radius}} = \frac{\text{arc (in minutes)}}{\text{radius (in miles)}}$$

$$= \frac{\text{meridional parts for lat. } l}{57{\cdot}29577 \times 60}$$

$\therefore$ meridional parts for lat. l

$$= 57{\cdot}29577 \times 60 \times 2{\cdot}3025881 \times \log_{10} \cot \tfrac{1}{2} l_1.$$

In logarithms—

log mer. parts for lat. $l = 3{\cdot}8984895 + \log_{10}(\text{L cot } \frac{1}{2} \text{colat.} - 10)$.

Whence we deduce the following

Rule for Finding the Meridional Parts.

Diminish the tabular logarithm of the cotangent of one-half the colatitude by 10. Find the logarithm of the remainder, and add to it the constant logarithm 3·8984895. The result is the logarithm of the meridional parts for the given latitude.

Preliminary principles.

Ex.—Required the meridional parts for latitude 65° and 65° 20′.

(1.)

L cot 12° 30′ − 10 = 0·6542448

Log. 0·6542448	= $\bar{1}$·8157403
Constant log.	= 3·8984895
	3·7142298
∴ Meridional parts,	= 5178·80

(2.)

L cot 12° 20′ − 10 = 0·6602609

Log. 0·6602609	= $\bar{1}$·8197155
Constant log.	= 3·8984895
	3·7182050
∴ Meridional parts,	= 5226·43

Relations between Meridional Difference of Latitude and Difference of Longitude, Course, &c.

It appears that on Mercator's chart the difference of longitude, meridional difference of latitude, and increased distance, form the sides of a right-angled triangle, and are proportional to the departure, true difference of latitude, and distance, in the triangle ABC. The two triangles are therefore similar.

If, then, in AB produced (fig. 4) AB′ be taken equal to mer. difference of latitude, and B′C′ be drawn parallel to BC, meeting AC produced in C′; the sides of the triangle AB′C′ will be the meridional difference of latitude, difference of longitude, and increased distance.

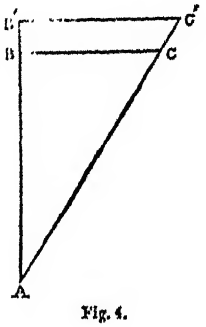

Fig. 4.

Hence, in equations (I.), (II.), (III.), (IV.), (V.), (VI.), (VII.), and (VIII.), we may substitute meridional difference of latitude for true difference of latitude, difference of longitude for departure, and increased distance for distance; and the equations will still hold.

The relation principally required is that which connects the meridional difference of latitude, difference of longitude, and course;

or, diff. long. = mer. diff. lat. × tan course.

Parallel Sailing.

When the course is 90°, or the ship sails in a parallel of latitude, the equations (I.), &c., give no result when applied to find the distance.

In this case we must apply the formula,

arc of parallel = corresponding arc of equator × cos lat.

Here the arc of the parallel corresponds to the distance, and the arc of equator is difference of longitude, and we have for parallel sailing

dist. = diff. long. × cosine lat.,

from which, any two of the quantities being given, the third may be found. Also, if d and d' be distances corresponding to the same difference of longitude in parallels l and l',

we have d = diff. long. cos l

d' = diff. long. cos l';

$$\text{or } d = d' \cdot \frac{\cos l}{\cos l'};$$

which enables us to find the distance on one parallel corresponding to a given distance on another, the difference of longitude being the same.

Middle-Latitude Sailing.

Since departure = diff. of longitude × cos. mid. latitude, if in equations (II.), (IV.), (VI.), (VIII.), we substitute this value for departure, we shall obtain the following equations:—

diff. long. × cos mid. lat. = dist. × sin course . . . (XI.)
diff. long. × cos mid. lat. = true diff. lat. × tan course . (XII.)
true diff. lat. = diff. long. × cos mid. lat. × cot course . (XIII.)
sin course = diff. long. × cos mid. lat. ÷ dist. . . . (XIV.)

from which all the rules for middle-latitude sailing may be derived.

Preliminary principles.

Traverse Tables.

A table in which the true difference of latitude and departure, corresponding to certain distances for every course, expressed in points and degrees, are laid down, is called a *traverse table*. It is very useful to enable the seaman to solve the several problems which occur in navigation by simple inspection. It must of course be calculated on some of the principles laid down in this chapter.

It is evident that as this table contains the relations of the sides and angles of a right-angled triangle, the solution of any right-angled triangle, whose sides represent any other quantities, will be given by it, by making the requisite changes.

Thus, the course remaining the same, if, for difference of latitude we look out in the table the meridional difference of latitude, the corresponding departure will be the difference of longitude; also, the difference of longitude can be found from the departure by these tables, by looking out the middle latitude as a course, and the departure as a true difference of latitude; then the corresponding distance is the difference of longitude.

SECT. II.—LONGITUDE AND LATITUDE.

PROB. I.—Given latitude from, and latitude in; to find the true difference of latitude.

Rule.—Under latitude in, with its proper name, *i.e.*, N. or S., place latitude from. Subtract the greater from the less, if of the same name, and reduce to minutes. The result is the true difference of latitude required, and is of the same or different name with latitude in, according as latitude in is greater or less than latitude from. If they are of different names, *add* and affect with the name of latitude in.

Ex. 1.—A vessel sails from the Lizard, Lat. 49° 58′ N., to Cape St Vincent, Lat. 37° 3′ N.; what is the true diff. of latitude?

Latitude in	37° 3′ N.
Latitude from	49 58 N.
True diff. latitude	12 55 S. = 775 miles S.

Ex. 2.—A vessel sails from New York, Lat. 40° 42′ N., to Liverpool, Lat. 53° 25′ N.; find the true diff. of latitude.

Latitude in	53° 25′ N.
Latitude from	40 42 N.
True diff. latitude	12 43 N. = 763 miles N.

Ex. 3.—A ship sailed from Funchal, Lat. 32° 38′ N., to the Cape of Good Hope, Lat. 34° 29′ S.; what is the true diff. of latitude?

Latitude in	34° 29′ S.
Latitude from	32 38 N.
True diff. latitude	67 7 S. = 4027 miles S.

PROB. 2.—Given the latitude from, and true difference of latitude; to find latitude in.

Rule.—If the latitude from and true difference be of the same name, add them (the true difference of latitude being turned, if necessary, into degrees and minutes); the sum is the latitude in of the same name. If of unlike names, under latitude from place the true difference of latitude, subtract the less from the greater; the result, with the name of the greater, is the latitude in.

Ex. 1.—A ship sailed from the Lizard, 49° 58′ N., and made good, in a northerly direction, 207 miles; what is the latitude in?

Latitude from	49° 58′ N.
True diff. latitude	3 27 N.
Latitude in	53 25 N.

Ex. 2.—A ship in Lat. 57° 18′ N. sailed due S. 3789 miles; what is the latitude in?

Latitude from	57° 18′ N.
True diff. latitude	63 9 S.
Latitude in	5 51 S.

Preliminary principles.

PROB. 3.—To find the meridional difference of latitude; having given latitude from, and latitude in. Take the meridional parts for the two latitudes from the table for meridional parts; subtract if the names be alike, and add if the names be unlike. The result is the meridional difference of latitude, and is N. or S. according as the latitude in is N. or S. of latitude from.

Ex. 1.—Required the meridional diff. of latitude in sailing from Cape Finisterre, Lat. 42° 52′ N., to Port Praya, in the island of Santiago, Lat. 14° 54′ N.

Latitude in.....	14° 54′ N.	Mer. parts.....	904 N.
Latitude from.....	42 52 N.	Mer. parts.....	2852 N.
		Mer. diff. lat....	1948 S.

Ex. 2.—To find the meridional diff. of latitude in sailing from Lat. 5° 35′ N. to 8° 17′ S.

Latitude in.....	8° 17′ S.	Mer. parts.....	499 S.
Latitude from.....	5 35 N.	Mer. parts.....	335 N.
		Mer. diff. lat....	834 S.

PROB. 4.—To find the difference of longitude; having given longitude in, and longitude from.

Rule.—Under longitude in place longitude from; subtract, if of like name; reduce the result to minutes, and call it E. or W., according as longitude in is E. or W. of longitude from. Add, if of unlike names, and attach the name E. or W., according as the longitude in is E. or W. of longitude from. If the longitude found by this rule exceed 180° it must be subtracted from 360°, and affected with the contrary name.

Ex. 1.—A ship sails from Liverpool, Long. 2° 59′ W., to New York, Long. 73° 59′ W.; required the diff. of longitude.

Longitude in.....	73°	59′	W.	
Longitude from.....	2	59	W.	
Diff. Longitude.....	71	0	W.	=4260 miles W.

Ex. 2.—A ship sails from Maskelyne's Isles, in Long. 167° 59′ E., to Olinda, in Long. 35° 54′ W.; find the diff. of longitude.

Longitude in.....	35°	54′	W.	
Longitude from.....	167	59	E.	
	203	53	W.	
	360	0		
Diff. longitude.....	156	7	E.	=9367 miles E.

PROB. 5.—To find the longitude in; having given longitude from, and difference of longitude.

Rule.—Under longitude from place difference of longitude. If of like names, add, and the result is the longitude in of the same name as the longitude from; if of unlike names, subtract the less from the greater. The result, with the name of the greater, is the longitude in.

Ex. 1.—A ship from Long. 9° 54′ E. sailed westerly till the difference of longitude was 1398 miles; what is the longitude in?

Longitude from.....	9°	54′	E.
Diff. longitude.....	23	18	W.
Longitude in.....	13	24	W.

Ex. 2.—The longitude sailed from is 25° 9′ W., and diff. of longitude 112° 6′ W.; find longitude in.

Longitude from.....	25°	9′	W.
Diff. longitude.....	18	46	W.
Longitude in.....	43	55	W.

SECT. III.—OF MEASURING A SHIP'S RUN IN A GIVEN TIME.

The method commonly used at sea to find the distance sailed in a given time is by means of a log-line and half-minute glass. (A description of these is given under the articles LOG, and LOG-LINE, which see.)

The interval between two consecutive knots on the line —also technically called a *knot*—is supposed to be the same fraction of a nautical mile (6080 feet) that half a minute is of an hour. Hence the proper length of a knot is $\frac{6080}{120}$ =51 feet nearly. But although the line and glass be at any time perfectly adjusted to each other, yet as the line shrinks after being wet, and as the weather has a considerable effect on the glass, it will be necessary to examine them from time to time; and the distance given by them must be corrected accordingly. The distance sailed, therefore, may be affected by an error in the glass or in the line, or in both. The true distance may, however, be found as follows:—

Preliminary principles.

PROB. 1.—The distance sailed by the log, and the seconds run by the glass, being given; to find the true distance run, the line being supposed right.

Let the number of seconds in which the glass runs out be n, and let d and d' be the true distance and distance by log respectively. Then evidently the longer the time the glass is running, the less is the distance by log compared with the true distance, and conversely. Hence we have the proportion—

$$d : d' :: 30'' : n'';$$

or true dist. : dist. by log :: 30″ : number of seconds the glass is running;

$$\text{or } d = \frac{d' \times 30}{n}.$$

Rule.—Multiply the distance given by log by 30, and divide by the number of seconds the glass is running; the result is the true distance run.

Ex. 1.—The hourly rate of sailing by the log is 9 knots, and the glass is found to run out in 35″; required the true rate of sailing.

9
30
35)270(7·7=true rate of sailing.

Ex. 2.—The distance sailed by the log is 73 miles, and the glass runs out in 26″; required the true distance.

73
30
26)2190(84·2=the true distance.

PROB. 2.—Given the distance sailed by the log, and the measured interval between two adjacent knots on the line; to find the true distance, the glass running exactly 30″.

Here evidently the true distance is greater or less than the distance by log, as the measured interval is greater or less than 51 feet.

Let a be the measured interval between the knots in feet, and d and d' the true, and measure distances as before.

Then $51 : a :: d' : d$,

or 51 feet : measured distance in feet :: distance by log : true distance

$$\therefore \text{True distance} = \text{distance by log.} + \frac{\text{measured distance.}}{51}$$

Rule.—Multiply the distance given by log by the measured length of a knot, and divide by 51; the quotient is the true distance.

Ex. 1.—The hourly rate of sailing by the log is 5 knots, and the interval between knot and knot measures 53 feet; required the true rate of sailing.

53
5
51)265(5·19=true rate of sailing.

Ex. 2.—The distance sailed is 85 miles, by a log line which measures 42 feet to a knot; required the true distance run.

85
42
170
340
51)3570(70=true distance run.
3570

PROB. 3.—Given the length of a knot, the number of seconds run by the glass in half a minute, and the distance

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sailed by the log. To find the true distance we must evidently compound the ratios given in problems 1 and 2 and we have

$$n \times 51 : 30 \times a :: d' : d;$$

$$\text{or } d = d' \times \frac{30a}{51n} = \frac{d' \cdot 10a}{17n}.$$

Rule.—Multiply the distance given by the log by 10 times the measured distance between the knots, and divide by 17 times the number of seconds the glass is running.

Ex.—The distance sailed by the log is 159 miles, the measured length of a knot is 42 feet, and the glass runs out in 33″; required the true distance.

Distance by the log..... 159
10 times length of a knot 420
3180
17 times number of seconds run by the glass..... 636
561)66780(119·037=true distance.

SECT. IV.—ON COURSES AND CORRECTIONS OF COURSES.

Mariner's Compass.

A ship is enabled to keep her course at sea by means of an instrument called the mariner's compass. It consists of a magnetic steel bar attached to the under side of a card, divided into points and quarter points, and supported by a fine pin, on which it turns freely within a box covered with glass. By reason of the directive property of the magnet, the north point, which is commonly denoted by a *fleur de lis*, is readily known. The circumference of the card is generally divided into thirty-two points, which, in the best compasses, are again subdivided into half points and quarters. These are reckoned sufficient for nautical purposes. On the inside of the box is drawn a dark vertical line called lubber's point. This point, or rather line, and the pin on which the card turns, are in the same line or plane with the keel of the ship; and hence the point on the circumference of the card opposite to lubber's point shows the angle which the ship's course makes with the magnetic meridian, called the course of the ship.

The annexed diagram (fig. 5) gives a general view of

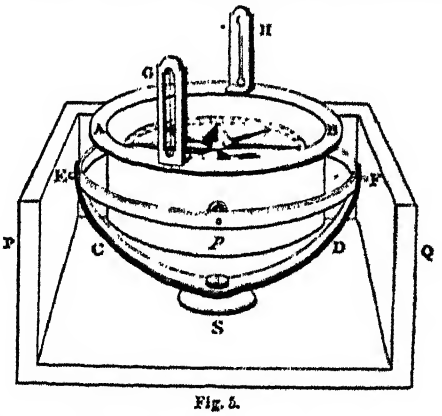

Fig. 5.

the compass. (For a full explanation of its magnetic properties, see MAGNETISM.) The names of the points, and the angles which they form with the meridian, are given in fig. 6, and as thus represented the instrument is called the steering compass.

The azimuth compass is the same instrument more nicely made. The circumference of the card is divided into degrees and parts by a vernier, and is fitted up with sight-vanes to take amplitudes and azimuths, for the purpose of determining the variation of the compass by observation. The variation is then applied to the magnetic course shown by the steering compass, whence the true course, with respect to the meridian, becomes known.

Besides the variation, the needle is also affected by the dip, which is likewise fully explained in the article MAGNETISM, as well as Mr Barlow's method of correcting the

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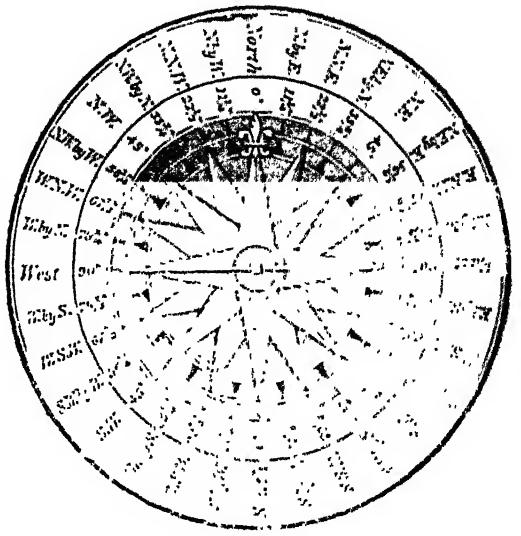

Fig. 6.

effects of local attraction, arising from the effects of the iron, guns, &c., in the vessel itself.

The compass course generally differs from the true course on account of three causes:—1. The variation of the compass; 2. The deviation of the compass; 3. The leeway. We shall now explain how these errors are to be applied.

1. *The Variation of the Compass.*—This is fully explained under the article MAGNETISM, which see. The mode of ascertaining its amount will be given hereafter.

PROB. I.—To find the true course, having given compass course.

Rule 1.—Allow easterly variation to the right, and allow westerly variation to the left.

Ex. 1.—The compass course is W.N.W., and variation 3¼ pts. W.; find the true course.

	Pts.	qrs.	
Compass course	6	0	left of N.
Variation	3	1	left of N.
True course.....	9	1	left of N., or W. by S ¼ S.

Ex. 2.—The compass course is S.W.¾W., and variation 2½ E.; find the course.

	Pts.	qrs.	
Compass course	4	3	right of S.
Variation	2	2	right of S.
True course.....	7	1	right of S., or W. by S ¼ W.

Ex. 3.—The compass course is N.W., the variation is 3¼ E.; required the true course.

	Pts.	qrs.	
Compass course.....	4	0	left of N.
Variation.....	3	1	right of N.
True course.....	0	3	left of N., or N ¾ W.

PROB. II.—Given the true course, to find the compass course.

Rule 2.—Allow easterly variation to the left, and westerly to the right.

Ex. 1.—The true course is N.N.E.½E., and variation 1¼ W.; find the compass course.

	Pts.	qrs.	
True course	2	2	right of N.
Variation	1	2	right of N.
Compass course ...	4	0	right of N., or N.E.

Ex. 2.—The true course is N ¾E., the variation 3¼ E.; required the compass course.

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	Pts.	qrs.	
True course	0	3	right of N.
Variation	3	1	left of N.
Compass course	2	2	left of N., or N.N.W.½W.

2. *The Deviation of the Compass.*—This error arises from the effects of local attraction, and varies with every different position of the ship's head. Several methods are employed in order to ascertain its amount. That most commonly adopted is to place a compass on shore, out of reach of the ship's attraction, and to take the bearing of the ship's compass, or some other object in the same direction with it; while at the same time the bearing of the compass on shore is taken on board. If now 180° be added to the bearing of the shore compass, so as to bring it round to the opposite point, the difference between this augmented bearing and the bearing at the ship's compass will be the amount of deviation for that position of the ship's head.

Suppose the ship's head is N., and that the reading off at the shore compass is S. 17° 15′ W., and that the reading off at the ship's compass is N. 20° E. Adding 180′ to the bearing of the shore compass, we get S. 197° 15′ W., or N. 17° 15′ E.; and subtracting this from the bearing of the ship's compass, N. 20° E., we get the deviation equal to 2° 45′ E., when the ship's head is N. The ship is now turned round, so that the head points successively to every point of the compass, and the deviation for each position found as before.

A table is then made, showing the deviation for every point of the compass. The deviation so found is treated exactly as the *variation*,—*i.e.*, in correcting the compass course to find the true course, easterly deviation is allowed to the right, and westerly deviation to the left; and conversely, to find the compass course from the true course, easterly deviation is allowed to the left, and westerly deviation to the right. Hence it appears, that when both variation and deviation are given, we may consider the latter as a correction of the former—to be added to it if of the same name, and to be subtracted from it if of the opposite name.

Ex. 1.—The compass course is S.W.¾W., variation 1¾ E., and deviation ½W.; what is the true course?

	Pts.	qrs.	
Compass course	4	3	right of S.
Variation	1	3	right
Deviation		2	left
	1	1	right.
True course	6	0	right of S., or W.S.W.

Ex. 2.—The compass course is W.½N., the variation 2½ W., and deviation ¾ W.; what is the true course?

	Pts.	qrs.	
Compass course	7	2	left of N.
Variation	2	2	left
Deviation	0	3	left
	3	1	left.
True course	10	3	left of N., or S.W. by W.¼W.

Ex. 3.—The true course is N.N.W.¾W., variation 1¾ E., and deviation ¼ W.; required the compass course.

	Pts.	qrs.	
True course	2	3	left of N.
Variation	1	3	left.
Deviation	0	1	right.
	1	2	left.
Compass course	4	1	left of N., or N.W.¼W.

The following table is taken from the monthly examination-papers at the Royal Naval College, Portsmouth, and will serve as a specimen of the tables which ought to be made for all ships:—

Deviation of the Compass of H.M.S. Vesuvius for different positions of the Ship's Head.

Direction of Ship's Head.	Deviation of Compass.	Direction of Ship's Head.	Deviation of Compass.
N.	2° 45′ E.	S.	3° 0′ W.
N. by E.	4 57	S. by W.	4 20
N.N.E.	7 30	S.S.W.	5 0
N.E. by N.	9 0	S.W. by S.	6 7
N.E.	10 0	S.W.	7 0
N.E. by E.	10 55	S.W. by W.	7 27
E.N.E.	10 40	W.S.W	7 50
E. by N.	9 55	W. by S.	8 20
E.	8 50	W.	8 50
E. by S.	7 15	W. by N.	8 10
E.S.E.	5 35	W.N.W.	6 50
S.E. by E.	3 40	N.W. by W.	5 40
S.E.	1 50	N.W.	4 50
S.E. by S.	0 20 E.	N.W. by N.	3 20
S.S.E.	0 56 W.	N.N.W.	1 40 W.
S. by E.	2 20	N. by W.	1 10 E.

3. *Leeway.*—The effect of the action of the wind upon the sails and hull of a ship is sometimes to produce a motion of the ship in a direction at right angles to that of the head or apparent course, as well as in this latter direction. The true course, therefore, is not that given by the compass, but that which is due to the composition of the two velocities of the ship,—viz., that in the direction of its head, and that at right angles to this direction. To obtain the true course from the compass course, therefore, we must add or subtract the angle of leeway, which is the angle between the compass course and the true course.

If the wind be on the right of a person on board ship who is looking towards the head, the real course is then evidently to the *left* of the direction of the ship's head,—*i.e.*, of the apparent course. If the wind be on his left hand, the true course is to the right. In the former case the ship is said to be on the *starboard tack*, and in the latter on the *port tack*. Whence is derived the rule for obtaining the true course from the compass course.

Rule.—If the ship is on the starboard tack, allow leeway to the left; if on the port tack, allow leeway to the right. Conversely, to obtain the compass course from the true course on the starboard tack, allow leeway to the right; if on the port tack, allow it to the left.

There are many circumstances which prevent laying down accurate rules for the allowance of leeway. The construction of different vessels, their trim with regard to the nature and quantity of cargo, the position and area of sail set, the velocity of the ship and the swell of the sea, are all susceptible of great variation, and very much affect the leeway.

The following rules are usually given for the purpose:—

1. When a ship is close-hauled under all sail, the water smooth, and with a light breeze, *allow no leeway.*
2. When the top-gallant sails are handed, *allow one point.*
3. Under close-reefed topsails *allow two points.*
4. When one topsail is handed, *allow two points and a half.*
5. When both topsails are handed, *allow three points.*
6. When the fore-course is handed, *allow four points.*
7. When under mainsail only, *allow five points.*
8. Under balanced mizen, *allow six points.*
9. Under bare poles, *allow seven points.*

These rules, however, are not much to be depended upon. A very good method of estimating the leeway is to observe the bearing of the ship's wake as frequently as may be judged necessary, which may be conveniently enough done by drawing a small semicircle on the tafferel, with its diameter at right angles to the ship's length, and dividing its circumference into points and quarters. The angle contained between the semi-diameter which points right aft,

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and that which points in the direction of the wake, is the leeway. But the best and most rational way of finding the leeway is to have a compass or semicircle on the tafferel, as before described, with a low crutch or swivel in its centre; after heaving the log, the line may be slipped into the crutch just before it is drawn in, and the angle it makes on the limb with the line drawn right aft, will show the leeway very accurately.

Ex. 1.—A ship's apparent course is S.S.W.½W., leeway 2½ points, the wind being S.E.½E.; required the true course. In this case the wind is on the left of the vessel, or it is on the port tack, and leeway must be allowed to the right.

	Pts.	qrs.	
Apparent course.....	2	3	right of S.
Leeway	2	2	right of S.
True course.....	5	1	right of S., or S.W. by W.¼W.

Ex. 2.—The apparent course is N.N.W., leeway 1½ points, and wind E.N.E. Here the vessel is on the starboard tack.

	Pts.	qrs.	
Apparent course.....	2	0	left of N.
Leeway	1	2	left of N.
True course.....	3	2	left of N., or N.W. by N.¼W.

Ex. 3.—The true course of a ship is S.E.½S., leeway 2½ points, and wind N.N.E.; required the compass course. Here the ship is on the port tack.

	Pts.	qrs.	
True course	3	2	left of S.
Leeway	2	2	right of S.
Compass course.....	1	0	left of S., or S. by E.

Chap. II.—ON PLANE SAILING.

Plane sailing is the art of navigating a ship upon principles deduced from the notion of the earth's being an extended plane. On this supposition, the meridians are considered parallel lines. The parallels of latitude are at right angles to the meridians; the lengths of the degrees on the meridians, equator, and parallels of latitude are everywhere equal; and the degrees of longitude are reckoned on the parallels of latitude as well as on the equator; and consequently the departure and difference of longitude are equal. In fact, in the right-angled triangle ABC (fig. 7), where AB is the true difference of latitude, BAC the course, AC the distance, and BC the departure, which is assumed equal to the difference of longitude; all the problems in sailing are solved by the relations of the sides and angles of the single right-angled triangle ABC. Except, however, for a small portion of the earth's surface near the equator, the departure cannot be assumed equal to the difference of longitude without very considerable error; and the longitude in cannot be at all depended on when found by this method. If, however, the departure be an element, this method is correct.

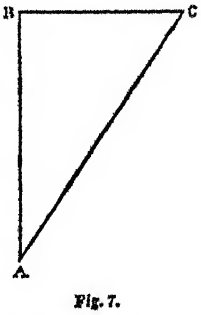

Fig. 7.

In fig. 7, A is the place from which the ship sails; AB the meridian, and equal to the true difference of latitude; BC perpendicular to the meridian, and equal to the departure. It is always possible and easy to construct a right-angled triangle when two parts, of which one is a side, beside the right angle, are given. Consequently problems in navigation may always be solved by construction, with the aid of the rule and compasses. In making constructions for this purpose, it is only necessary to attend to the following convention:—Let the upper part of the paper or plan on which the drawing is to be made represent the *north*; then the lower part will be *south*, the right-hand side *east*, and the left-hand side *west*. This convention we have already tacitly assumed in treating of the corrections of the courses.

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To make a Construction.

A north and south line is to be drawn, to represent the meridian of the place *from* which the ship sailed; and the upper or lower end of this line is to be marked as the position of the place, according as the course is southerly or northerly. From this point as centre, with the chord of 60° (on the rule), an arc of a circle is to be described from the meridian, towards the right or left, according as the course is easterly or westerly; and the course, taken from the line of chords if given in degrees, but from the line of rhumbs if expressed in points of the compass, is to be laid on this arc, beginning from the meridian. A straight line drawn through this point and the point sailed from is the direction of the distance, which, if given, must be laid down on this line, beginning at the point sailed from. A straight line is to be drawn from the extremity of the distance perpendicular to the meridian; and hence the true difference of latitude and the departure will be found.

If the true difference of latitude be given, it is to be laid down on the meridian, beginning at the point from which the ship sailed; and a straight line drawn through the extremity of the difference of latitude, perpendicular to the meridian, to meet the distance sailed, will limit the figure, and enable us to find the parts required.

If the departure be given, it is to be laid off on a parallel, and the line drawn through its extremity will limit the distance.

If the distance and true difference of latitude be given, through the extremity of the true difference of latitude draw a straight line perpendicular to the meridian; extend a pair of compasses to the given distance, place one of its points at the place from which the ship sailed, and let the other point be in the perpendicular line first drawn; join this point with the point *from*, and the triangle is determined, and the course and departure found.

If the departure and distance are given, with the point *from* as centre and the distance as radius, describe an arc of a circle. Let the departure be laid off on a parallel, so that one point is in the meridian and the other in the circle just described. Join this latter point with the point *from*, and the triangle is formed. The general mode of solving problems in plane sailing has already been given in chap. i., sect. 2. The following examples will show how the formulæ are to be applied:—

Obs. **It is to be distinctly understood that the above method cannot be applied to obtain the difference of longitude without very sensible error.**

***Ex.* 1.—A ship from St Helena, in Lat. 15° 55′ S. sailed S.W. by S. 158 miles; required the latitude in, and departure.**

***By Construction.*—Draw the meridian AB (fig. 8), and with the chord of 60° describe the arc mn, and make it equal to the rhumb of three points; and through n draw AC equal to 158 miles; from C draw CB perpendicular to AB; then AB applied to the scale from which AC was taken will be found to measure 131·4, and BC 87·8.**

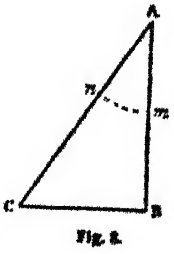

Fig. 8.

***By Calculation.*—To find the true difference of latitude.**

L cosine of course.....	3 pts.	= 9·91985
Log. distance	158 m.	= 2·19886
		−10
Log. true diff. lat.....		= 2·11871
Hence, true diff. lat.....		= 131·4 S.

To find departure.

L sin course	3 pts.	= 9·74474
Log. distance	158 m	= 2·19886
		−10
Log. departure.....	87·8	= 1·94360

Plane Sailing.

By Inspection.—In the traverse table, the difference of latitude answering to the course 3 points, and distance 158 miles, in a distance column, is 131·4, and departure 87·8.

By Gunter's Scale.—The extent from 8 points to 5 points, the complement of the course on the line of sine rhumbs (marked S. R.) will reach from the distance 158 to 131·4, the difference of latitude on the line of numbers; and the extent from 8 points to 3 points on sine rhumbs will reach from 158 to 87·8, the departure on numbers.[1]

Latitude St Helena	15° 55′ S.
Diff. latitude	2 11 S.
Latitude in	18 6 S.

Ex. 2.—A ship from St George's, in Lat. 38° 45′ N., sailed S.E.½S., and the latitude by observation was 35° 7′ N.; required the distance run, and departure.

Latitude St George's	38° 45′ N.
Latitude in	35 7 N.
Diff. latitude	3 38=218 miles S.

By Construction.—Draw the portion of the meridian AB (fig. 9) equal to 218 miles; from the centre A, with the chord of 60°, describe the arc *mn*, which make equal to the rhumb of 3½ points; through A*n* draw the line AC, and from B draw BC perpendicular to AB, and let it be produced till it meets AC in C. Then the distance AC being applied to the scale will measure 282 miles, and the departure BC 179 miles.

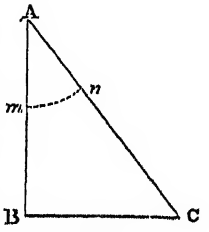

Fig. 9.

By Calculation.—To find the distance.

L sec of the course	3½ pts.	=	10·11181
Log. true diff. latitude	218 m.	=	2·33846
		−10	
Log. distance		=	2·45027
Or distance	= 282		

To find departure.

L tan of the course	3½ pts.	=	9·91417
Log. true diff. latitude	218 m.	=	2·33846
		−10	
Log. departure		=	2·25263
Or departure	= 178·9		

By Inspection.—Find the given difference of latitude 218 miles in latitude column, under the course of 3½ points; opposite to which, in distance column, is 282 miles; in departure column 178·9 m.; the distance and departure required.

By Gunter's Scale.—Extend the compass from 4½ points, the complement of the course, to 8 points on sine rhumbs; that extent will reach from the difference of latitude 218 miles to the distance 282 miles on numbers; and the extent from 4 points to the course 3½ points on the line of tangent rhumbs (marked T. R.) will reach from 218 miles to 178·9, the departure on numbers.

Ex. 3.—A ship from Palma, in Lat. 28° 37′ N., sailed N.W. by W., and made 192 miles of departure; required the distance run, and the latitude come to.

By Construction.—Make the departure BC (fig. 10) equal to 192 miles, draw BA perpendicular to BC, and from the centre C, with the chord of 60°, describe the arc *mn*, which make equal to the rhumb of 3 points, the complement of the course; draw a line through C*n*, which produce till it meet BA in A. Then the distance AC being measured, will be equal to 231 m., and the difference of latitude AB will be 128·3 miles.

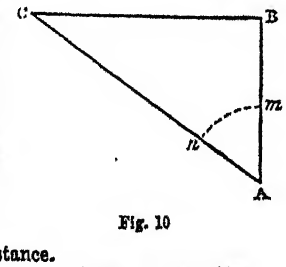

Fig. 10

By Calculation.—To find the distance.

L cos of course	5 pts.	=	10·08015
Log. departure	192 m.	=	2·28330
		−10	
Log. distance	230·9	=	2·36345

To find the true difference of latitude.

L cot of course	5 pts	=	9·82489
Log. departure	192 m.	=	2·28330
		−10	
Log. true diff. latitude	128·3	=	2·10819

By Inspection.—Find the departure 192 miles in its proper column above the given course 5 points; and opposite thereto is the distance 231 miles, and difference of latitude 128·3, in their respective columns.

By Gunter's Scale.—The extent from 5 points to 8 points on the line of sine rhumbs, being laid from the departure 192 on numbers, will reach to the distance 231 on the same line; and the extent from 5 points to 4 points on the line of tangent rhumbs will reach from the departure 192, to the difference of latitude 128·3 on numbers.

Latitude of Palma	28° 37′ N.
Diff. latitude	2 8 N.
Latitude in	30 45 N.

Ex. 4.—A ship from a place in Lat. 43° 13′ N., sails between the north and east 285 miles, and is then by observation found to be in Lat. 46° 31′ N.; required the course and departure.

Latitude sailed from	43° 13′ N.
Latitude by observation	46 31 N.
Diff. of latitude	3 18=198 miles.

By Construction.—Draw the portion of the meridian AB (fig. 11) equal to 198 miles; from B draw BC perpendicular to AB; then take the distance 285 miles from the scale, and with one foot of the compass in A describe an arc intersecting BC in C, and join AC. With the chord of 60° describe the arc *mn*, the portion of which contained between the distance and difference of latitude, applied to the line of chords, will measure 46°, the course; and the departure BC being measured on the line of equal parts, will be found equal to 205 miles.

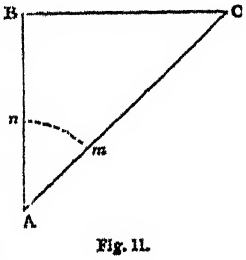

Fig. 11.

By Calculation.—To find the course.

Log. true diff. latitude	(198)	+ 10 =	12·29660
Log. distance	285	−	2·45484
L cos course	46°	=	9·84176
Or course is	N. 46° 0′ E.		

To find the departure.

L sin course	46°	=	9·85693
Log. distance	285	=	2·45484
		−10	
Log. departure	205	=	2·31177

By Inspection.—Find the given distance in the table in its proper column; and if the difference of latitude answering thereto is the same as that given, namely, 198, then the departure will be found in its proper column, and the course at the top or bottom of the page, according as the difference of latitude is found in a column marked *lat.* at top or bottom. If the difference of latitude thus found does not agree with that given, turn over till the nearest thereto is found to answer to the given distance. This is in the page marked 46 degrees at the bottom, which is the course, and the corresponding departure is 205 miles.

By Gunter's Scale.—The extent from the distance 285 to the difference of latitude 198 on numbers, will reach from 90° to 44°, the complement of the course on sines; and the extent from 90° to the course 46° on the line of sines being laid from the distance 285, will reach to the departure 205 on the line of numbers.

Ex. 5.—A ship from Fort-Royal, in the island of Grenada, in Lat. 12° 9′ N., sailed 260 miles between the south and west, and made 190 miles of departure; required the course and latitude come to.

[1] For the method of resolving the various problems in navigation by the Sliding Gunter, the reader is referred to Dr Mackay's Treatise on the Description and Use of that instrument.

Plane Sailing.

By Construction.—Draw BC perpendicular to AB, and equal to the given departure 190 miles; then from the centre C, with the distance 260 miles, sweep an arc intersecting AB in A, and join AC. Now describe an arc from the centre A with the chord of 60°, and the portion *mn* of this arc, contained between the distance and difference of latitude, measured on the line of chords, will be 47°, the course; and the difference of latitude AB, applied to the scale of equal parts, measures 177¾ miles.

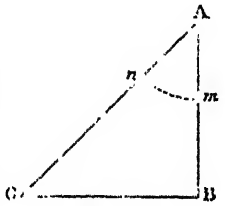

Fig. 12.

By Calculation.—To find the course.

Log. departure	190 + 10	=	12·27875
Log. distance	200	=	−2·41497
L sin course	46° 57′	=	9·86378

Or course is..... S. 46° 57′ W.

To find the true difference of latitude.

L cos course	46° 57′	=	9·83419
Log. distance	260	=	2·41497
			−10
Log. true diff. latitude	177·3	=	2·24916

By Inspection.—Seek in the traverse table until the nearest to the given departure is found in the same line with the given distance 260. This is found to be in the page marked 47° at the bottom, which is the course; and the corresponding difference of latitude is 177·3.

By Gunter's Scale.—The extent of the compass, from the distance 260 to the departure 190 on the line of numbers, will reach from 90° to 47°, the course on the line of sines; and the extent from 90° to 43°, the complement of the course on sines, will reach from the distance 260 to the difference of latitude 177½ on the line of numbers.

Latitude Fort-Royal	12° 9′	N.
Difference of latitude	177 = 2 57	S.
Latitude in	9 12	N.

Ex. 6.—A ship from a port in Lat. 7° 56′ S. sailed between the south and east till her departure was 132 miles, and was then, by observation, found to be in Lat. 12° 3′ S.; required the course and distance.

Latitude sailed from	7° 56′	S.
Latitude in, by observation	12 3	S.
Difference of latitude...4	7 = 247	

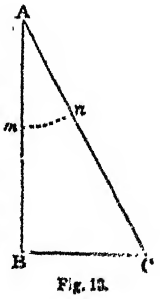

Fig. 13.

By Construction.—Draw the portion of the meridian AB equal to the difference of latitude 247 miles; from B draw BC perpendicular to AB, and equal to the given departure 132 miles, and join AC; then with the chord of 60° describe an arc from the centre A; and the portion *mn* of this arc, being applied to the line of chords, will measure about 28°; and the distance AC, measured on the line of equal parts, will be 280 miles.

By Calculation.—To find the course.

Log. departure	132 + 10	=	12·12057
Log. true diff. latitude	247	=	2·39270
L tan course	28° 7′	=	9·72787

Or course is.....S. 28° 7′ E.

To find the distance.

L sec course	28° 7′	=	10·05454
Log. true diff. latitude	247	=	2·39270
			−10
Log. distance	280	=	2·44724

By Inspection.—Seek in the table till the given difference of latitude and departure, or the nearest thereto, are found together in their respective columns, which will be under 28°, the required course; and the distance answering thereto is 280 miles.

By Gunter's Scale.—The extent from the given difference of latitude 247 to the departure 132 on the line of numbers, will reach from 45° to 28°, the course on the line of tangents; and the extent from 62°, the complement of the course, to 90° on the sines, will reach from the difference of latitude 247 to the distance 280 on numbers.

The six problems whose solutions are illustrated above are all that occur in the solution of the right-angled triangle whose sides represent the true difference of latitude, departure, and distance, and one of whose angles is the course. Mercator's Sailing.

Chap. III.—On Mercator's Sailing.

We have already explained the principle of Mercator's Chart, and have shown that in every problem of navigation there is a second right-angled triangle similar to that whose solutions formed the subject of investigation in chapter ii.; and the sides of which, corresponding to the true difference of latitude and departure, are the meridional difference of latitude and difference of longitude.

We have already given a rule for finding the meridional parts for any given latitude, on the supposition that the earth is a perfect sphere. If the earth's oblateness be taken into account, and the compression, *i.e.*, the ratio of the difference of the equatorial and polar semi-diameters to the equatorial semi-diameter, be taken as $\frac{1}{300}$, which it is very nearly, the meridional parts for latitude l will be given by the formula—

$$\text{Mer. parts} = 7915{\cdot}705 \log.\tan.\left(45^\circ + \frac{l}{2}\right) - 22{\cdot}88 \sin l - 0{\cdot}0508 \sin 3l - \&c.$$

Let AD (fig. 14) be the meridian, BAC the course, AB the true difference of latitude, AD the meridional difference of latitude; then

DE is the diff. long., and

ED = DA × tan BAC; or,

diff. long. = mer. diff. lat. × tan course;

or log. diff. long. = log. mer. diff. lat. + L tan course − 10.

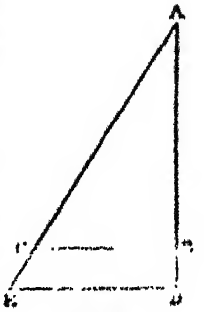

Fig. 14.

Also, by similar triangles, ADE and ABC, we have

DE : BC :: DA : BA; or,

$$DE = \frac{BC \times DA}{BA}$$

$$\therefore \text{diff. long.} = \frac{\text{dep.} \times \text{mer. diff. lat.}}{\text{true diff. lat.}}; \text{ or,}$$

log. diff. long. = log. dep. + log. mer. diff. lat. − log. true diff. lat.

Whence, from the departure and true and meridional differences of latitude, the difference of longitude may be found. The following examples will illustrate the mode of using these formulæ:—

Ex. 1. A ship sails from Cape Finisterre, Lat. 42° 52′ N., Long. 9° 17′ W., to Port Praya, in the island of Santiago, Lat. 14° 54′ N., and Long. 23° 29′ W.; required the course and distance.

Lat. from	42° 52′	N.	Mer. parts ... 2852
Lat. in	14 54	N.	Mer. parts ... 904
Diff. of lat.	27 58	S.	Mer. diff. lat. 1948 S.
	1678	S.	
Long. from	9° 17′	W.	
Long. in	23 29	W.	
Diff. long.	14 12 = 852	W.	

By Construction.—Draw the straight line AD (fig. 15), to represent the meridian of Cape Finisterre, upon which lay off AB, AD, equal to 1678 and 1948, the true and meridional differences of latitude. From D draw DE perpendicular to AD, and equal to the difference of longitude 852; join AE, and draw BC parallel to DE; then the distance AC will measure 1831 miles, and the course BAC 23° 37′.

Fig. 15.

By Calculation.—To find the course.

Log. diff. long.	852 + 10	=	12·93044
Log. mer. diff. lat.	1948	=	3·28939
L tan course	23° 37′	=	9·64095

Or course is .....S. 23° 37′ W.

Mercator's Sailing.

To find the distance.

L sec. course	23° 27′	=	10·03798
Log. true diff. lat.	1678 miles	=	3·22479
		−10	
Log. distance	1831	=	3·26277

Ex. 2.—A ship from Cape Henlopen in Virginia, in Lat. 38° 47′ N., Long. 75° 4′ W., sailed 267 miles N.E. by N.; required the ship's present place.

By Construction.—With the course, and distance sailed, construct the triangle ABC (fig. 16), and the difference of latitude AB being measured, is 222 miles; hence the latitude in is 42° 29′ N., and the meridional difference of latitude 293. Make AD equal to 293, and draw DE perpendicular to AD, and meeting AC produced in E; then the difference of longitude DE being applied to the scale of equal parts, will measure 196; longitude in is therefore 71° 48′ W.

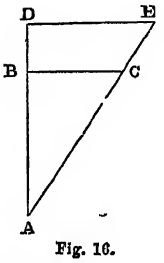

Fig. 16.

By Calculation.—To find the true difference of latitude.

L cos course	3 points	=	9·91985
Log. distance	267 miles	=	2·42651
		−10	
Log. true diff. latitude	222 N.	=	2·34636
Lat. from	= 38° 47′ N.	Mer. parts	2528
True diff. lat.	= 3 42 N.		
Lat. in	= 42 29 N.	Mer. parts	2821
		Mer. diff. lat.	293

To find the difference of longitude.

L tan course	3 points	=	9·82489
Log. mer. diff. lat.	293 miles	=	2·46687
		−10	
Log. diff. long.	195·8 E.	=	2·29176
Long. from	75° 4′ W.		
Diff. long.	3 16 E.		
Long. in	71 48 W.		

Ex. 3.—A ship from Port Canso in Nova Scotia, in Lat. 45° 20′ N., Long. 60° 55′ W., sailed S.E.¼S., and, by observation, was found to be in Lat. 41° 14′ N.; required the distance sailed, and longitude come to.

Lat. Port Canso	45° 20′ N.	Mer. parts 3058
Lat. in, by observation	41 14 N.	Mer. parts 2720
Diff. lat.	4 6=246	Mer. diff. lat. 338

By Construction.—Make AB (fig. 17) equal to 246, and AD equal to 338; draw AE, making an angle with AD equal to 3¾ points, and draw BC, DE perpendicular to AD. Now AC being applied to the scale, will measure 332, and DE, 306.

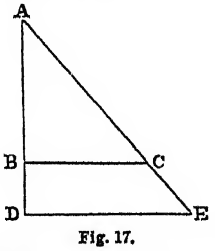

Fig. 17.

By Calculation.—To find the distance.

L sec course	3¾ points	=	10·13021
Log. true diff. lat.	246 miles	=	2·39093
		−10	
Log. distance	332	=	2·52114

To find the difference of longitude.

L tan course	3¾ points	=	9·95729
Log. mer. diff. lat.	338 miles	=	2·52892
		−10	
Log. diff. long.	306·3 E.	=	2·48621
Long. Port Canso from	60° 55′ W.		
Diff. long.	5 6 E.		
Long. in	55 49 W.		

Ex. 4.—A ship sailed from Sallee, in Lat. 33° 58′ N., Long. 6° 20′ W., the corrected course was N.W. by W.½W., and departure 420 miles; required the distance run, and the latitude and longitude in.

By Construction.—With the course and departure construct the triangle ABC (fig. 18); now AC and AB being measured, will be found to be equal to 476 and 224 respectively; hence the latitude in is 37° 42′ N., and meridional difference of latitude 276. Make AD equal to 276, and draw DE perpendicular thereto, meeting the distance produced in E.; then DE applied to the scale will be found to measure 516. The longitude in is therefore 14° 56′ W.

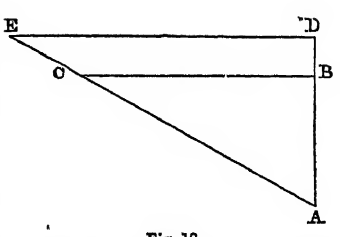

Fig. 18.

By Calculation.—To find the distance.

L cos course	5½ points	=	10·05457
Log. dep.	420 miles	=	2·62325
		−10	
Log. dist.	476·2	=	2·67782

To find true difference of latitude.

L cot course	5½ points	=	9·72796
Log. dep.	420 miles	=	2·62325
		−10	
Log. diff. latitude	224·5	=	2·35121
Latitude Sallee from	33° 58 N.	Mer. parts	2169
Diff. latitude	3 44 N.		
Latitude in	37 42 N.	Mer. parts	2445
		Mer. diff. lat.	276

To find the difference of longitude.

L tan course	5½ points	=	10·27204
Log. mer. diff. latitude	276 miles	=	2·44091
		−10	
Log. diff. longitude	516·3	=	2·71295

Or—

Log. dep.	420	=	2·62325
Log. mer. diff. latitude	276	=	2·44091
			5·06416
Log. true diff. latitude		=	2·35121
Log. diff. longitude	516·3	=	2·71295

Ex. 5.—A ship from St Mary's, in Lat. 36° 57′ N., Long. 25° 9′ W., sailed on a direct course between the north and east 1162 miles, and was then, by observation, in Lat. 49° 57′ N.; required the course steered, and longitude come to.

Latitude of St Mary's	36° 57′ N.	Mer. parts	2389
Latitude in	49 57 N.	Mer. parts	3470
Diff. latitude	13 0 N.	Mer. diff. lat.	1081 N.
	780 N.		

By Construction.—Make AB equal to 780, and AD equal to 1081; draw BC, DE, perpendicular to AD; make AC equal to 1162, and through A and C draw ACE. Then the course or angle A being measured, will be found equal 47° 50′, and the difference of longitude DE will be 1194.

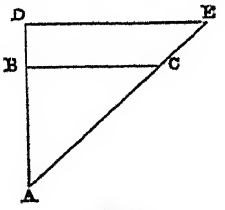

Fig. 19.

By Calculation.—To find the course.

Log. true diff. latitude	780+10	=	12·89209
Log. dist.	1162	=	3·06521
L cos course	47° 50′	=	9·82688

To find difference of longitude.

L tan course	47° 50′	=	10·04302
Log mer. diff. latitude	1081 miles	=	3·03383
		−10	
Log. diff. longitude	1194	=	3·07685
Longitude from	25° 9′ W.		
Diff. longitude	19 54 E.		
Longitude in	5 15 W.		

Ex. 6.—From Aberdeen, in Lat. 57° 9′ N., Long. 2° 8′ W., a ship sailed between the south and east till her departure was 146 miles, and Lat. in 53° 32′ N.; required the course and distance run, and longitude in.

Mercator's Sailing.

Latitude Aberdeen ..... 57° 9′ N. Mer. parts... 4199
Latitude in ..... 53 32 N. Mer. parts..... 3817
Diff. latitude ..... 3 37 = 217 S. Mer. diff. lat... 382

By Construction.—With the difference of latitude 217 miles, and departure 146 miles, construct the triangle ABC; make AD equal to 382, draw DE parallel to BC, and produce AC to E; then the course BAC will measure 33° 56′, the distance AC, 261, and the difference of longitude DE, 257.

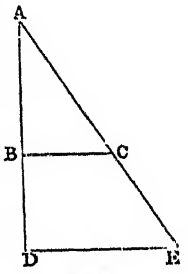

Fig. 20.

By Calculation.—To find the course.

Log. dep.	146 + 10 =	12·16435
Log. true diff. lat...	217 =	2·33646
L tan course...	33° 56′ =	9·82789

To find the distance.

L sec course	33° 56′ =	10·08109
Log. true diff. latitude	217 miles =	2·33646
	−10	
Log. dist.....	261·5 =	2·41755

To find the difference of longitude.

Log. mer. diff. latitude	382 =	2·58206
Log. dep.....	146 =	2·16435
		4·74641
Log. true diff. latitude	217 =	2·33646
Log. diff. longitude	257 =	2·40995

Longitude from ..... 2° 8′ W.
Diff. longitude ..... 4 17 E.
Longitude in ..... 2 9 E.

Ex. 7.—A ship from Naples, in Lat. 40° 51′ N., Long. 14° 14′ E., sailed 252 miles on a direct course between the south and west, and made 173 miles of westing; required the course made good, and the latitude and longitude in.

By Construction.—With the distance and departure make the triangle ABC as formerly. Now the course BAC being measured by means of a line of chords, will be found equal to 43° 21′, and the difference of latitude applied to the scale of equal parts will measure 183; hence the latitude in is 37° 48′ N., and meridional difference of latitude 237. Make AD equal to 237, and complete the figure, and the difference of longitude DE will measure 224; hence the longitude in is 10° 30′ E.

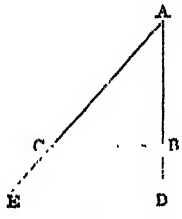

Fig. 21.

By Calculation.—To find the course.

Log. dep.	173 + 10 =	12·23805
Log. dist.	252 =	2·40140
L sin course.....	43° 21′ =	9·83665

To find the true difference of latitude.

L cos course.....	43° 21′ =	9·86164
Log. dist.....	252 miles =	2·40140
	−10	
Log. true diff. latitude	183·2 =	2·26304

Latitude from (Naples) .... 40° 51′ N. Mer. parts... 2690
True diff. latitude ..... 3 3 S.
Latitude in ..... 37 48 N.. Mer. parts... 2453
Mer. diff. lat. 237

To find the difference of longitude.

L tan course	43° 21′ =	9·97497
Log. mer. diff. latitude.....	237 miles =	2·37475
	−10	
Log. diff. longitude	223·7 =	2·34972

Longitude from..... 14° 14′ E.
Diff. longitude..... 3 44 W.
Longitude in..... 10 30 E.

Ex. 8.—A ship from Terceira, in Lat. 38° 45′ N., Long. 27° 6′ W., sailed on a direct course, which, when corrected, was N. 32° E., and is found, by observation, to be in Long. 18° 24′ W.; required the latitude come to, and distance sailed.

Traverse Sailing, or Compound Courses.

Longitude of Terceira..... 27° 6′ W.
Longitude in ..... 18 24 W.
Diff. longitude..... 8 42 = 522

By Construction.—Make the right-angled triangle ADE, having the angle A equal to the course 32°, and the side DE equal to the difference of longitude 522; then AD will measure 835, which, added to the meridional parts of the latitude left, will give those of the latitude come to, 48° 46′; hence the difference of latitude is 601. Make AB equal thereto, to which let BC be drawn perpendicular; then AC applied to the scale will measure 708 miles.

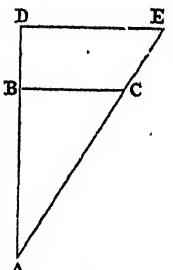

Fig. 22.

By Calculation.—To find meridional difference of latitude.

L cot course	32° 0′ =	10.20421
Log. diff. longitude.....	522 miles =	2·71767
	−10	
Log. mer. diff. latitude.....	835·2 N. =	2·92188

Latitude from Tercera ..... 38° 45′ N. Mer. parts... 2526
Mer. diff. lat. 835
Latitude in ..... 48 46 N. 3361
True diff. latitude .... 10 1 N. = 601 miles N.

To find the distance.

L sec course	32° 0′ =	10·07158
Log. true diff. latitude.....	601 miles =	2·77887
	−10	
Log. dist.	707·1 =	2·85045

Chap. IV.—ON TRAVERSE SAILING, OR COMPOUND COURSES.

It is the first business of the navigator, when he is about to conduct a ship from one port to another, to calculate beforehand the course on which the vessel is to be steered, and the distance she must run on that course. If the sea is perfectly free from obstruction between the two ports, one course and one distance will suffice for this purpose. It very seldom happens, however, that the sea is free from obstruction; but rocks or shoals, islands or some part of a mainland, intervenes, and a change of course is thus rendered necessary. In this case, the course and distance of the vessel, supposing the navigation unobstructed, having been taken from the chart, the mariner will determine how many changes of course are necessary, and will proceed to calculate the several courses and distances which shall be equivalent to the one course and distance on which the vessel would sail if unobstructed. This calculation, it must be remarked, is very different from that of the course and distance actually made good on a given day, when, by reason of variation of winds and other causes, the course requires to be altered; although naturally the modes of making these calculations are similar. In the former case, however, the distances to be dealt with are very much greater, and the changes of course less frequent, than in the latter.

The investigations of this chapter are intended to guide the navigator in making his preliminary calculation; the mode of correcting the course and calculating the distance run in each day will form the subject of a subsequent investigation.

If a ship sail on two or more courses in a given time, the irregular track she describes is called a traverse; and to resolve a traverse is the method of reducing these several courses and distances run into a single course and distance.

Rule 1.—Make a table sufficiently large to contain the several courses, &c. Divide this table into six columns; the courses are to be put in the first, and the corresponding distances in the second column; the third and fourth columns are to contain the differences of latitude, and the two last the departures.

Traverse Sailing, or Compound Courses.

The several courses and their corresponding distances being properly arranged in the table, find the true difference of latitude and departure answering to each in the traverse table, remembering that the true difference of latitude is to be put into a N. or S. column according as the course is in a northern or southern direction, and that the departure is to be put in E. or W. column according as the course is easterly or westerly. Add together these several quantities in each of the columns, and set the sum down at the bottom. The difference between the sums in the N. and S. columns will be the true difference of latitude made good, of the same name with the greater; and the difference between the sums of the E. and W. columns is the departure made good, of the same name with the greater sum.

Look in the traverse table for a true difference of latitude and departure agreeing as nearly as possible with those above; then the distance will be found on the same line, and the course at the top or bottom of the page, according as the true difference of latitude is greater or less than the departure, since in the former case the course is less than 45° or 4 points, and in the latter case greater.

Having found the latitude, find also the meridional difference of latitude; and to the course and meridional difference of latitude in a latitude column, the corresponding departure will be the difference of longitude, which, applied to the longitude from, will give the longitude in.

It is also easy to resolve a traverse by construction; and we now show how this may be done, although it is scarcely ever practised at sea.

Describe a circle with the chord of 60° as radius, and in it draw two diameters at right angles to each other, at whose extremities are to be marked the initials of the cardinal points, N. being uppermost.

Lay off each course on the circumference, reckoned from its proper meridian; and from the centre to each point draw lines, which are to be marked with the proper number of the course.

On the first radius lay off the first distance from the centre, and through its extremity, and parallel to the second radius, draw the second distance of its proper length; through the extremity of the second distance, and parallel to the third radius, draw the third distance of the proper length; and so on until all the distances are drawn.

A line drawn from the extremity of the last distance to the centre of the circle will represent the distance made good; and a line drawn from the same point perpendicular to the meridian, produced if necessary, will represent the departure; and the portion of the meridian intercepted between the centre and departure will be the difference of latitude made good.

To construct for the difference of longitude we must find by the table the meridional difference of latitude, and lay it off on the meridian, and then complete the triangle similar to that whose sides represent the true difference of latitude; distance and departure as usual.

Ex. 1.—A ship from Fayal, in Lat. 38° 32′ N., and Long. 28° 36′ W., sailed as follows:—E.S.E., 163 miles; S.W.½W., 110 miles; S.E.¼S., 180 miles; and N. by E. 68 miles: required the latitude and longitude in, the course, and distance made good.

Course.	Dist.	Diff. of Lat.		Departure.	
		N.	S.	E.	W.
E.S.E.	163	...	62·4	150·6	...
S.W.½W.	110	...	69·8	...	85·0
S.E.¼E.	180	...	144·5	107·2	...
N. by E.	68	66·7	...	13·3	...
		66·7	176·7	271·1	85·0
			66·7	85·0	
S. 41½° E.....	281		210·0	186·1	

Latitude from	38° 32′ N.	Mer. parts.....	2509
True diff. latitude.....	3 30 S.		
Latitude in	35 2 N.	Mer. parts.....	2247
		Mer. diff. lat...	262

Traverse Sailing, Compound Courses.

Now to course 41½°, and opposite 131, half the meridional difference of latitude in latitude column, stands 115 in a departure column, which doubled gives 230 for difference of longitude.

Longitude from.....	28° 36′ W.
Diff. longitude	3 50 E.
Longitude in.....	24 46 W.

By Construction.—With chord of 60° describe the circle NESW (fig. 23), the centre of which represents the place the ship sailed from. Draw two diameters NS, EW, at right angles to each other, the one representing the meridian, and the other the parallel of latitude of the place sailed from. Take each course from the line of rhumbs, lay it off on the circumference from its proper meridian, and number it in order, 1, 2, 3, 4. Upon the first rhumb C1, lay off the first distance 163 miles from C to A; through it draw the second distance AB parallel to C2, and equal to 110 miles; through B draw BD equal to 180 miles, and parallel to C3; and draw DE parallel to C4, and equal to 68 miles. Now CE being joined, will represent the distance made good, which, applied to the scale, will measure 281 miles. The arc Sn, which represents the course, being measured on the line of chords, will be found equal to 41½°. From E draw EF perpendicular to CS produced; then CF will be the difference of latitude, and FE the departure made good, which, applied to the scale, will be found to measure 210 and 186 miles respectively. On CF produced lay off to the scale CG equal to 262, the meridional difference of latitude; and through G draw GH parallel to FE, meeting CE produced in H. Then GH is the difference of longitude; and, when applied to the scale, will be found to measure 230 miles.

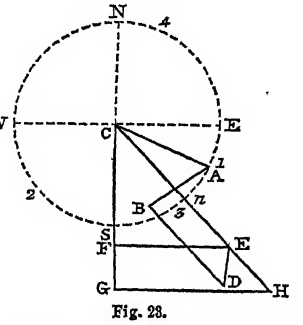

Fig. 23.

Although the above method is that usually employed at sea to find the difference of longitude, yet, as it has been already observed, it is not to be depended on, especially in high latitudes, long distances, and a considerable variation in the courses; in which case the following method becomes necessary:—

Rule 2.—Complete the traverse table as before, to which annex five columns. Now, with the latitude from, and the several differences of latitude, find the successive latitudes, which are to be placed in the first of the annexed columns; in the second, the meridional parts corresponding to each latitude are to be put; and in the third, the meridional differences of latitude.

Then to each course, and corresponding meridional difference of latitude, find the difference of longitude by *Ex.* 4, chap. iii., which place in the fourth or fifth columns, according as the course is easterly or westerly; and the difference between the sums of these columns will be the difference of longitude made good upon the whole, of the same name with the greater.

Remarks.

1. When the course is north or south, there is no difference of longitude.

2. When the course is east or west, the difference of longitude cannot be found by Mercator's Sailing; in this case the following rule is to be used:—

To the nearest degree to the given latitude taken as a course, find the distance answering to the departure in a latitude column; this distance will be the difference of longitude.

Ex. 2.—A ship from Lat. 78° 15′ N., Long. 28° 14′ E., sailed the following courses and distances, viz.:—W.N.W. 154 miles, S.W. 96, N.W.½W. 89, N. by E. 110, N.W.¼N. 56, S. by E.¼E. 78. The latitude in is required, and the longitude, by both methods; the bearing and distance of Hacluit's headland, in Lat. 79° 55′ N., Long. 11° 55′ E., is also required.

rallel iling.

Parallel Sailing.

TRAVERSE TABLE.

Courses.	Dist.	Diff. of Latitude. N.	Diff. of Latitude. S.	Departure. E.	Departure. W.
	...	...	...	...	...
W.N.W.	154	58·9	...	...	142·3
S.W.	96	...	67·9	...	67·9
N.W.¼W.	89	56·4	...	...	68·8
N. *by* E.	110	107·9	...	21·5	...
N.W.¾N.	56	45·0	...	...	33·4
S. *by* E.¾E.	78	...	73·4	26·3	...
		268·2	141·3	47·8	312·4
		141·3			47·8
		126·9			264·6

By Rule I.

Lat. from ....78° 15′ N. Mer. parts....7817
Diff. lat. .... 2 7 N.

Lat. in....80 22 N. Mer. parts....8504

Mer. diff. lat. 687

Log. mer. diff. lat.	687	= 2·83696
Log. dep.	264·6	= 2·42256
		5·25952
Log. true diff. lat.	126·2	= 2·10346
Log. diff. long.	143·2	= 3·15606

23° 52′ W.
Long. from .... 28 14 E.
Long. in.... 4 22 E.

The error of this method, in above example, is therefore 1° 23′.

LONGITUDE TABLE.

Successive Latitudes.	Merid. Parts.	Meridional Diff. of Lat.	Diff. of Longitude. E.	Diff. of Longitude. W.
78° 15′	7817	...	...	...
79 14	8120	303	...	731·7
78 6	7774	346	...	346·0
79 2	8056	282	...	343·6
80 50	8676	620	123·6	...
81 35	8970	294	...	218·0
80 22	8504	466	166·7	...
			290·3	1639·3
				290·3
				1349·0

Long. from .... 28° 14′ E.
Diff. long. .... 22 29 W.

Long. in.... 5 45 E.

To find the bearing and distance of Hacluit's headland—

Lat. H. H. = 79° 55′ N. M. P. 8347 Long. 11° 55′ E.
Lat. ship = 80 22 N. M. P. 8504 Long. 5 45 E.

Diff. lat. = 0 27 S. M. D. L. 157 Diff. long. 6 10 E.

370

Now, opposite to 78·5, half the meridional difference of latitude, and 185·0, half the difference of longitude, stands the course 67°; and opposite to the difference of latitude 27, the distance is 69 miles. Hence Hacluit's headland bears S. 67° E., distant 69 miles.

CHAP. V.—OF PARALLEL SAILING.

When the course is 8 points or 90° from the meridian,—*i.e.*, due E. or W.,—the true difference of latitude becomes =0, and the rules we have investigated in chaps. iii. and iv. fail to give any result. In this case the ship sails on a parallel of latitude. We have already proved in chap. i., that, neglecting the earth's oblateness, the arc of a parallel, in any given latitude, intercepted between two meridians, is equal to the corresponding arc of the equator, in other words, the difference of longitude, multiplied by the cosine of the latitude.

Whence we derive these three formulæ for parallel sailing:—

Distance = diff. longitude × cos latitude;
Cos latitude = distance ÷ diff. longitude;
Diff. longitude = distance × sec latitude.

Problems in parallel sailing may be solved by construction; for it is evident that we have only to construct a right-angled triangle whose hypothenuse is the difference of longitude, one of the sides the distance, and the angle between this side and the hypothenuse the latitude. Also it is evident, that in a traverse table, if we consider the latitude a course, and the difference of longitude a distance, the distance will be a true difference of latitude.

Ex. 1.—Required the number of miles contained in a degree of longitude in latitude 55° 58′.

By Construction.—Draw the indefinite right line AB (fig. 24); make the angle BAC equal to the given latitude 55° 58′, and AC equal to the number of miles contained in a degree of longitude at the equator, namely, 60; from C draw CB perpendicular to AB; and AB being measured on the line of equal parts, will be found equal to 33·5, the miles required.

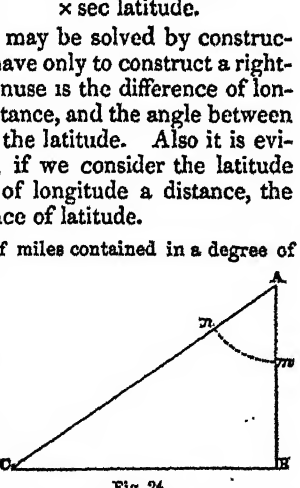

Fig. 24.

By calculation—

L cos lat	55° 58′	= 9·7479360
Log. miles in a degree	60	= 1·7781513
		−10
Log. miles in a deg. in lat. 55° 58′		= 1·5260873

By Inspection.—To 56°, the nearest degree to the given latitude, and distance 60 miles, the corresponding difference of latitude is 33·6, which is the miles required.

By Gunter's Scale.—The extent from 90° to 34°, the complement of the given latitude on the line of sines, will reach from 60 to 33·6 on the line of numbers.

There are two lines on the other side of the scale, with respect to Gunter's line, adapted to this particular purpose, one of which is entitled *chords*, and contains the several degrees of latitude; the other, marked M. L., signifying *miles of longitude*, is the *line of longitudes*, and shows the number of miles in a degree of longitude in each parallel. The use of these lines is therefore obvious.

Ex. 2.—Required the compass course and distance from A to B.

Given lat. A=17° 30′ S. Long. A= 9° 12′ E.
lat. B=17 30 S. Long. B=10 42 E.

Variation 1¾ E., and deviation as in the table on p. 13.

The true course is due E.

Also, long. A = 19° 12′ E.
long. B = 10 42 E.
Diff. long. = 1 30 =90 E.

Log. diff. long.	90	= 1·954243
L cos lat.	17° 30′	= 9·979419
		−10
Log. dist.	85·8 m.	= 1·933662

To find compass course.

	Pts.	qrs.	
True course	8	0	right of N.
Variation	1	3	left of N.
	6	1	right of N., or E.N.E.¼E.
Deviation by table 2° 55′ E., or	0	3	left of N.
Compass course	5	2	r. of N., or N.E. by E.¼E.

Parallel Sailing.

Ex. 3.—A ship sails from Treguier in France, Long. 3° 14′ W., to Gaspey Bay, Long. 64° 27′ W., the common Lat. being 48° 47′ N.; required the distance run.

Longitude from			3° 14′ W.
Longitude in			64 27 W.
			61 13=3673 W.
L cos latitude	48° 47′	=	9·8188250
Log. diff. longitude	3673	=	3·5650209
			−10
Log. distance run	2420	=	3·3838459

Ex. 4.—A ship from Cape Finisterre, Lat. 42° 52′ N., Long. 9° 17′ W., sailed due W. 342 miles; required the longitude in.

By Construction.—Draw the straight line AB (fig. 25), equal to the given distance 342 miles, and make the angle BAC equal to 42° 52′, the given latitude; from B draw BC perpendicular to AB, meeting AC in C; then AC applied to the scale will measure 466½, the difference of longitude required.

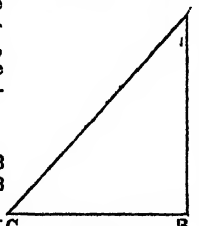

Fig. 25.

By Calculation—

L cosec lat.	42° 52′	=	10·13493
Log. distance	342	=	2·53403
			−10
Log. diff. long.	466·6	=	2·66896
Long. Cape Finisterre			9° 17′ W.
Diff. longitude			7 47 W.
Longitude in			17 4 W.

Ex. 5.—A ship sailed due E. 358 miles, and was found by observation to have differed her longitude 8° 42′; required the parallel of latitude.

By Construction.—Make the line AB (fig. 26) equal to the given distance; to which let BC be drawn perpendicular, with an extent equal to 522′, the difference of longitude; describe an arc from the centre A, cutting BC in C; then the angle BAC, being measured by means of the line of chords, will be found equal to 46¾°, the required latitude.

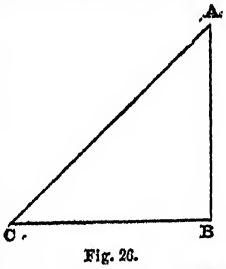

Fig. 26.

By Calculation—

Log. dist.	358+10	=	12·55388
Log. diff. long.	512	=	2·71767
L cos lat.	46° 42′	=	9·83621

Ex. 6.—From two ports in Lat. 33° 58′ N., distance 348 miles, two ships sail directly N. till they are in Lat. 48° 23′ N.; required their distance.

By Construction.—Draw the lines CB, CE (fig. 27), making angles with CP equal to the complements of the given latitudes, namely, 56° 2′ and 41° 37′ respectively. Make BD equal to the given distance 348 miles, and perpendicular to CP. Now from the centre C, with the radius CB, describe an arc intersecting CE in E; then EF drawn from the point E, perpendicular to CP, will represent the distance required; which being applied to the scale, will measure 278½ miles.

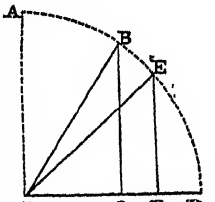

Fig. 27.

By Calculation, as under:—

Log. given distance	348 miles	=	2·54158
L cos lat. in	48° 23′	=	9·82226
			12·36384
L cos lat. from	33° 58′	=	9·91874
Log. distance required	278·6 miles	=	2·44510

Ex. 7.—Two ships, in Lat. 56° 0′ N., distant 180 miles, sail due S.; and having come to the same parallel, are now 232 miles distant. The latitude of that parallel is required.

By Construction.—Make DB (fig 28) equal to the first distance 180 miles, DM equal to the second 232, and the angle DBC equal to the given latitude 56°. From the centre C, with the radius CB, describe the arc BE; and through M draw ME parallel to CD, intersecting the arc BE in E. Join EC, and draw EF perpendicular to CD; then the angle ECF will be the latitude required; which, being measured, will be found equal to 43° 58′.

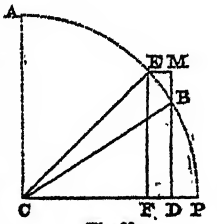

Fig. 28.

By Calculation, as under:—

L cos lat. from	56° 0′	=	9·74756
Log. distance on required parallel 232 miles		=	2·36549
			12·11305
Log. distance on known parallel	180	=	2·25527
L cos latitude in	43° 53′	=	9·85778

Middle-Latitude Sailing.

Chap. VI.—OF MIDDLE-LATITUDE SAILING.

It has been already explained in chap. ii. that the departure is greater than the intercepted arc of the parallel of the higher latitude, and less than that of the parallel of the lower of two places between which a ship sails; but that there is an intermediate parallel, the arc of which is exactly equal to the departure. This parallel is supposed to pass through the middle point between the extreme latitudes; and hence the latitude of this point is called the middle latitude. The relations between course, distance, departure, and true difference of latitude are to be found as in chap. iii.; and the relation between the departure and difference of longitude is given by the above considerations, viz.,—

Departure = diff. long. × cos mid. latitude.

But departure = true diff. lat. × tan course.

Hence we get

True diff. lat. × tan course = diff. long. × cos mid. lat. (A.)

also departure = distance × sin course.

Whence also

Distance × sin course = diff. long. × cos mid. lat. (B.)

If ABC (fig. 29) be the triangle for plane sailing, where AB is the true difference of latitude, AC the distance, BAC the course, and BC the departure; at C make BCD equal to the middle latitude, and produce CD to meet AB produced in D; then CD is evidently the true difference of longitude, and all the problems may be resolved and constructed by the two triangles which have a common side, —viz., the departure BC.

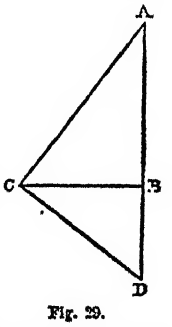

Fig. 29.

Also problems in middle-latitude sailing may be solved by the traverse table; for the relations between middle latitude, difference of longitude, and departure, are the same as those between course, distance, and true difference of latitude, and may therefore be found at once by inspection from the table.

Ex. 1.—Required the compass course and distance from the Island of May, in Lat. 56° 12′ N. and Long. 2° 37′ W., to the Naze of Norway, in Lat. 57° 50′ N., and Long. 7° 27′ E.; variation 2¼ W.

Latitude Isle of May	56° 12′ N.	56°	12′
Latitude Naze of Norway	57 50 N.	57	50
Difference of latitude	1 38=98′ N.	114	2
Middle latitude		57	1
Longitude Isle of May	2° 37′ W.		
Longitude Naze of Norway	7 27 E.		
Difference of longitude	10 4=604′ E.		

By Construction.—Draw the right line AD (fig. 30) to represent the meridian of the May; with the chord of 60° describe the arc *mn*, upon which lay off the chord of 32° 59′, the complement of the middle latitude from *m* to *n*. From D through *n* draw the line DC equal to 604′, the difference of longitude; and from C draw CB perpendicular to AD; make BA, equal to 98′, the difference of latitude, and join AC; which, applied to the scale, will measure 343 miles, the distance sought; and the angle A being measured by means of the line of chords, will be found equal to 73° 24′, the required course.

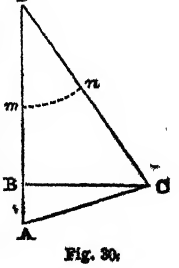

Fig. 30.

Middle-Latitude Sailing.

By Calculation.—To find the course.

L cos mid. latitude	57° 1′	=	9·73591
Log. diff. longitude	604 miles	=	2·78104
			12·51695
Log. true diff. latitude	98	=	1·99123
L tan course	73° 24′	=	10·52572

Or course = N. 73° 24′ E.

To find the distance.

L sec course	73° 24′	=	10·54411
Log. diff. latitude	98 miles	=	1·99123
			−10
Log. distance	343	=	2·53534

The true course is N. 73° 24′ E., or E.N.E.½E. nearly.

	Pts.	qrs.	
True course	6	3	right of N.
Variation	2	2	right of N.
	9	1	right of N., or E.S.E.½E.
Or	6	3	left of S.
Deviation	0	2	left of S.
Compass course	7	1	or E.½S.

Ex. 2.—A ship from Brest, in Lat. 48° 23′ N., and Long. 4° 30′ W., sailed S.W.½W. 238 miles; required the latitude and longitude in.

By Construction.—With the course and distance construct the triangle ABC (fig. 31), and the difference of latitude AB being measured will be found equal to 142 miles; hence the latitude in is 46° 1′ N., and the middle latitude 47° 12′. Now make the angle DCB equal to 47° 12′; and DC being measured will be 281, the difference of longitude; hence the longitude in is 9° 11′ W.

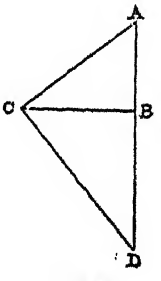

Fig. 31.

By Calculation.—To find the difference of latitude.

L cos course	4½ pts.	=	9·77503
Log. distance	238 miles	=	2·37658
			−10
Log. true diff. latitude	141·8	=	2·15161

Lat. Brest	48° 23′ N.		48° 23′ N.
Diff. latitude	2 22 S.	Half	1 11 S.
Latitude in	46 1 N.	Mid. lat.	47 12 N.

To find the difference of longitude.

Log. distance	238	=	2·37658
L sin course	4½ pts.	=	9·90483
		=	12·28141
Log. cos mid. latitude	47° 12′	=	9·83215
Log. diff. longitude	281·3	=	2·44926

Long. Brest	4° 30′	W.
Diff. longitude	4 41	W.
Longitude in	9 11	W.

Ex. 3.—A ship from St Antonio, in Lat. 17° 0′ N. and Long. 24° 25′ W., sailed N.W.½N., till, by observation, her latitude was found to be 28° 34′ N.; required the distance sailed, and longitude come to.

Latitude St Antonio	17° 0′ N.	17° 0′ N.
Latitude by observation	28 34 N.	28 34 N.
Diff. of latitude	11 34=694′	45 34 N.
	Middle latitude	22 47 N.

By Construction.—Construct the triangle ABC (fig. 32), with the given course and difference of latitude, and make the angle BCD equal to the middle latitude. Now the distance AC and difference of longitude DC being measured, will be found equal to 864 and 558 respectively.

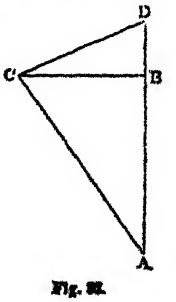

Fig. 32.

By Calculation.—To find the distance.

L sec course	3½ pts.	=	10·09517
Log. diff. latitude	694 miles	=	2·84136
			−10
Log. distance	864	=	2·93653

To find the difference of longitude.

L tan course	3½ pts.	=	9·87020
Log. diff. latitude	694 miles	=	2·84136
			12·71156
L cos mid. latitude	22° 47′	=	9·96472
Log. diff. longitude	558·3	=	2·74684

Long. St Antonio	24° 25′	W.
Diff. longitude	9 18	W.
Longitude in	33 43	W.

Middle Latitude Sailing.

Ex. 4.—A ship from Lat. 26° 30′ N., and Long. 45° 30′ W., sailed N.E.½N. till her departure is 216 miles; required the distance run, and latitude and longitude come to.

By Construction.—With the course and departure construct the triangle ABC (fig. 33); and the distance and difference of latitude being measured will be found equal to 340 and 263 respectively. Hence the latitude in is 30° 53′, and middle latitude 28° 42′. Now make the angle BCD equal to the middle latitude, and the difference of longitude DC applied to the scale will measure 246′.

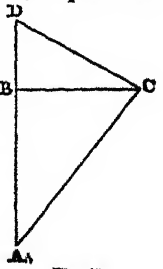

Fig. 33.

By Calculation.—To find the distance.

L cosec course	3½ pts.	=	10·19764
Log. departure	216 miles	=	2·33445
			−10
Log. distance	340·5	=	2·53109

To find the true difference of latitude.

L cot course	3½ pts.	=	10·08583
Log. departure	216 miles	=	2·33445
			−10
Log. true diff. latitude	263·2	=	2·42028

Latitude from	26° 30′ N.		26° 30′
Diff. latitude	4 23 N.	Half	2 12 N.
Latitude in	30 53 N.	Mid. lat.	28 42 N.

To find the difference of longitude.

L sec mid. latitude	28° 42′	=	10·05693
Log. departure	216 miles	=	2·33445
			−10
Log. diff. longitude	246·2	=	2·39138

Longitude from	45° 30′	W.
Diff. longitude	4 6	E.
Longitude in	41 24	W.

Ex. 5.—From Cape Sable, in Lat. 43° 24′ N., and Long. 65° 39′ W., a ship sailed 246 miles on a direct course between the S. and E., and was then by observation in Lat. 40° 48′ N.; required the course, and longitude in.

Latitude Cape Sable	43° 24′ N.	43° 24′ N.
Latitude by observation	40 48 N.	40 48 N.
Diff. of latitude	2 36=156 S.	Sum 84 12 N.
	Middle latitude	42 6 N.

By Construction.—Make AB (fig. 34) equal to 156 miles, draw BC perpendicular to AB, and make AC equal to 246 miles; draw CD, making with CB an angle of 42° 6′, the middle latitude. Now DC will be found to measure 256, and the course or angle A will measure 50° 39′.

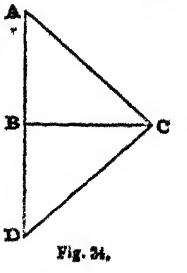

Fig. 34.

By Calculation.—To find the course.

Log. diff. latitude 156 + 10		=	12·19312
Log. dist.	246	=	2·39093
L cos course	50° 39′	=	9·80219

To find the difference of longitude.

Log. dist.	246	=	2·39093
L sin course	50° 39′	=	9·88834
			12·27927
L cos mid. latitude	42° 6′	=	9·87039
Log. diff. longitude	256·4	=	2·40 88

Middle-Latitude Sailing.

Longitude from .....65° 39′ W.
Diff. longitude ..... 4 16 E.
Longitude in .....61 23 W.

Ex. 6.—A ship from Cape St Vincent, in Lat. 37° 2′ N., Long. 9° 2′ W., sails between the S. and W.; the latitude in is 18° 16′ N., and departure 838 miles; required the course and distance run, and longitude in.

Latitude Cape St Vincent	37° 2′ N.	37° 2′ N.
Latitude in	18 16 N.	18 16 N.
Difference of latitude	18 46=1126 S.	Sum 55 18 N.
		Middle latitude...27 39 N.

By Construction.—Make AB (fig. 35) equal to the difference of latitude 1126 miles, and BC equal to the departure 838, and join AC; draw CD so as to make an angle with CB equal to the middle latitude 27° 39′. Then the course being measured on chords is about 36½°, and the distance and difference of longitude, measured on the line of equal parts, will be found to be 1403 and 946 respectively.

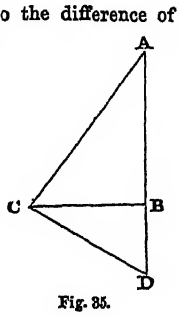

Fig. 35.

By Calculation.—To find the course.

Log. departure.....838+10=		12·92324
Log. diff. latitude	1126 =	3·05154
L tan course.....	36° 39′ =	9·87170

To find the distance.

L sec course	36° 39′ =	10·09566
Log. diff. latitude	1126 =	3·05154
		−10
Log. dist.	1403 =	3·14720

To find the difference of longitude.

Log. departure	838 =	2·92324
L sec mid. latitude	27° 39′ =	10·05266
		−10
Log. diff. longitude	946 =	2·97590

Longitude from..... 9° 2′ W.
Diff. longitude .....15 46 W.
Longitude in .....24 48 W.

Ex. 7.—A ship from Bordeaux, in Lat. 44° 50′ N., and Long. 0° 35′ W., sailed between the N. and W. 374 miles, and made 210 miles of westing; required the course, and the latitude and longitude in.

By Construction.—With the given distance and departure make the triangle ABC (fig. 36). Now the course, being measured on the line of chords, is about 34½°, and the difference of latitude on the line of numbers is 309 miles; hence the latitude in is 49° 59′ N., and middle latitude 47° 25′. Then make the angle BCD equal to 47° 25′, and DC being measured, will be 310 miles, the difference of longitude.

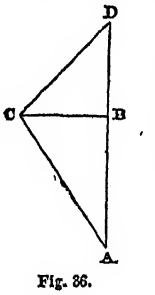

Fig. 36.

By Calculation.—To find the course.

Log. departure .....210+10=		12·32222
Log. distance.....	374 =	2·57287
L sin course	34° 10′ =	9·74935

To find the true difference of latitude.

L cos course.....	34° 10′ =	9·91772
Log. distance.....	374 =	2·57287
		−10
Log. diff. latitude.....	309·4 =	2·49059

Latitude from.....	44° 50′ N.		44° 50′ N.
True diff. latitude.....	5 9 N.	Half.....	2 35 N.
Latitude in	49 59 N.	Mid. lat.	47 25 N.

To find the difference of longitude.

L sec mid. latitude	47° 25′ =	10·16963
Log. departure.....	210 =	2·32222
		−10
Log. diff. longitude	310·3 =	2·49185

Oblique Sailing.

Longitude from .....0° 35′ W.
Diff. longitude.....5 10 W.
Longitude in .....5 45 W.

Ex. 8.—A ship from Lat. 54° 56′ N., Long. 1° 10′ W., sailed between the N. and E. till, by observation, she was found to be in Long. 5° 26′ E., and has made 220 miles of easting; required the latitude in, course, and distance run.

Longitude from .....1° 10′ W.
Longitude in .....5 26 E.
Difference of longitude 6 36=396 E.

By Construction.—Make BC (fig. 37) equal to the departure 220, and CD equal to the difference of longitude 396; then the middle latitude BCD being measured, will be found equal to 56° 15′; hence the latitude come to is 57° 34′, and difference of latitude 158′. Now make AB equal to 158, and join AC, which, applied to the scale, will measure 271 miles. Also the course BAC, being measured on chords, will be found equal to 54½°.

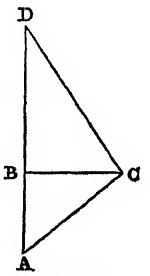

Fig. 37.

By Calculation.—To find the middle latitude.

Log. diff. of longitude.....396+10=		12·59769
Log. departure	220 =	2·34242
L sec mid. latitude	56° 15′ =	10·25527

Double middle latitude.....112° 30′ N.	
Latitude from.....	54 56 N.
Latitude in.....	57 34 N.
True diff. latitude.....	2 38=158 miles N.

To find the course.

Log. departure	220+10=	12·34242
Log. diff. latitude	158 =	2·19866
L tan course	54° 19′ =	10·14376

To find distance.

L sec course.....	54° 19′ =	10·23410
Log. diff. latitude	158 =	2·19866
		−10
Log. distance..	270·9 =	2·43276

Ex. 9.—A ship from a port in N. Lat., sailed S.E.½S. 438 miles, and differed her Long. 7° 28′; required the latitudes from and in.

By Construction.—With the course and distance construct the triangle ABC (fig. 38), and make DC equal to 448, the given difference of longitude. Now the middle latitude BCD will measure 48° 58′, and the difference of latitude AB 324 miles; hence the latitude from is 51° 40′, and latitude in 46° 16′.

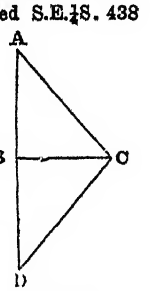

Fig. 38.

By Calculation.—To find the true difference of latitude.

L cos course.....	3¾ pts. =	9·86979
Log. distance	438 miles =	2·64147
		−10
Log. true diff. latitude.....324·5	=	2·51126

To find middle latitude.

Log. distance	438 ms. =	2·64147
L sin course	3¾ pts. =	9·82708
		12·46855
Log. diff. longitude	448 =	2·65128
L cos mid. latitude	48° 58′ =	9·81727

Mid. latitude	48° 58′ N.
Half diff. latitude	2 42 S.
Latitude from.....	51 40 N.
Latitude in.....	46 16 N.

Chap. VII.—OF OBLIQUE SAILING.

Oblique sailing is the application of oblique-angled plane triangles to the solution of problems at sea. This sailing

Oblique Sailing.

will be found particularly useful in going along shore, and in surveying coasts and harbours.

Ex. 1.—At 11 A.M. the Girdle Ness bore W.N.W., and at 2 P.M. it bore N.W. by N.; the course during the interval S. by W. five knots an hour; required the distance of the ship from the Ness at each station.

By Construction.—Describe the circle NESW (fig. 39), and draw the diameters NS, EW at right angles to each other. From the centre C, which represents the first station, draw the W.N.W. line CF; and from the same point draw CH, S. by W., and equal to 15 miles, the distance sailed. From H draw HF in a N.W. by N. direction, and the point F will represent the Girdle Ness. Then the distances CF, HF will measure 19·1 and 26·5 miles respectively.

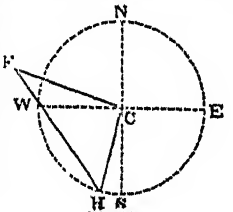

Fig. 39.

By Calculation.—In the triangle FCH are given the distance CH 15 miles, the angle FCH equal to 9 points, the interval between the S. by W. and W.N.W. points, and the angle CHF equal to 4 points, being the supplement of the angle contained between the S. by W. and N.W. by N. points. Hence CFH is 3 points; to find the distances CF, HF.

To find the distance CF.

Log. CH	15 m.	=	1·17609
L sin CHF	4 pts.	=	9·84948
			4·02557
L sin CFH	3 pts.	= −	9·74474
Log. CF	19·07 m.	=	1·28083

To find the distance FH.

Log. CH	15 m.	=	1·17609
L sin FCH	9 pts. = L sin 7 „	=	9·99157
			11·16766
L sin CFH	3 pts.	= −	9·74474
Log. FH	26·48 m.	=	1·42292

Ex. 2.—Running up Channel E. by S. per compass at the rate of 5 knots an hour. At 11 A.M. the Eddystone Lighthouse bore N. by E.¼E., and the Start Point N.E. by E.¼E.; and at 4 P.M. the Eddystone bore N.W. by N., and the Start N.¼E.; required the distance and bearing of the Start from the Eddystone, the variation being 2¼ points W.

By Construction.—Let the point C (fig. 40) represent the first station, from which draw the N. by E.¼E. line CA, the N.E. by E.¼E. line CB, and the E. by S. line CD, which make equal to 25 miles, the distance run in the elapsed time. Then from D draw the N.W. by N. line DA, intersecting CA in A, which represents the Eddystone; and from the same point draw the N.¼E. line DB, cutting CB in B, which therefore represents the Start. Now the distance AB applied to the scale will measure 22·9, and the bearing per compass BAF will measure 73½°.

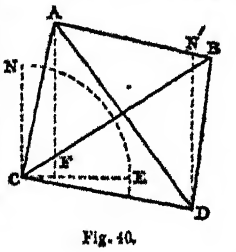

Fig. 40.

By Calculation—

The angle ACD = ACE + ECD = NCE − NCA + ECD
= 8 − 1¼ + 1 pt. = 7¾ pts.
BCD = NCE − NCB + ECD = 8 − 5¼ + 1 pt. = 3¾ pts.
ACB = ACD − BCD ..... = 4 pts.
ADC = N′DC − N′DA ..... = 7 − 3 pts. = 4 pts.
N′DB ..... = ¾ pts.
and CDB = N′DC + N′DB ..... = 7¾ pts.
Also, CAD = 16 pts. − ACD − ADC
= 16 − 7¾ − 4 pts. ..... = 4¼ pts.
and CBD = 16 − BCD − CDB ... = 16 − 3¾ − 7¾ = 4¼ pts.

To find AC.

Log. CD	25 m.	=	1·39794
L sin ADC	4 pts.	=	9·84948
			11·24742
L sin CAD	4¼ pts.	= −	9·86979
Log. AC	23·86 m.	=	1·37763

To find BC.

Log. CD	25 m.	=	1·39794
L sin BDC	7¾ pts.	=	9·99948
			11·39742
L sin CBD	4¼ pts.	= −	9·88818
Log. BC	32·30 m.	=	1·50924

To find BAC.

BC − AC		=	8·44
BC + AC		=	56·16
Log. (BC − AC)	8·44 m.	=	0·92634
L cot ½ACB	2 pts.	=	10·38278
			11·30912
Log. (BC + AC)	56·16	= −	1·74943
L tan ½(BAC − ABC)	19° 56′	=	1·55969

½(BAC + ABC) = 67 30
∴ BAC = 87 26
ABC = 47 34

Hence BAF = BAC − CAF
= 87° 26′ − 1¼ pts.
= 87° 26′ − 14° 4′
= 73° 22′ = 73⅓° nearly.

To find AB, or the distance.

Log. BC	32·30 m.	=	1·50924
L sin ACB	4 pts.	=	9·84948
		=	11·35972
L sin CAB	87° 26′	=	9·99956
Log. AB	22·9 m.	=	1·36016

Many other examples might be given. These and all other cases which can occur in practice are to be resolved by plane trigonometry, from calculating the triangles which the *data* of the given case afford.

Windward Sailing.

CHAP. VIII.—OF WINDWARD SAILING.

Windward sailing is when a ship by reason of a contrary wind is obliged to sail on different tacks in order to gain her intended port; and the object of this sailing is to find the proper course and distance to be run on each tack.

Ex.—The wind at N.W., a ship bound to a port 64 miles to the windward proposes to reach it on three boards,—two on the starboard and one on the larboard tack, and each within 5 points of the wind; required the course and distance of each tack.

By Construction.—Draw the N.W. line CA (fig. 41) equal to 64 miles; from C draw CB W. by S., and from A draw AD parallel thereto and in an opposite direction. Bisect AC in E, and draw BED parallel to the N. by E. rhumb, meeting CB, AD in the points B and D. Then CB = AD applied to the scale will measure 36¼ miles, and BD = 2CB = 72½ miles.

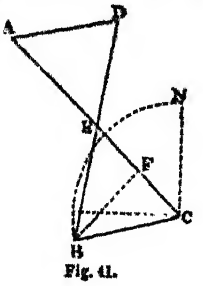

Fig. 41.

CHAP. IX.—OF CURRENT SAILING.

The computations in the preceding chapters have been performed upon the assumption that the water has no motion. This may no doubt answer tolerably well in those places where the ebbings and flowings are regular, as then the effect of the tide will be nearly counterbalanced. But in places where there is a constant current or setting of the sea towards the same point, an allowance for the change of the ship's place arising therefrom must be made. And the method of resolving these problems in which the effect of a current or heave of the sea is taken into consideration is called *current sailing*

Current Sailing.

In a calm, it is evident a ship will be carried in the direction and with the velocity of the current. Hence if a ship sails in the direction of the current, her rate will be augmented by the rate of the current; but if sailing directly against it, the distance made good will be equal to the difference between the ship's rate as given by the log and that of the current. And the absolute motion of the ship will be ahead if her rate exceeds that of the current; but if less, the ship will make sternway. If the ship's course be oblique to the current, the distance made good in a given time will be represented by the third side of a triangle, whereof the distance given by the log, and the drift of the current in the same time, are the other sides; and the true course will be the angle contained between the meridian and the line actually described by the ship.

It is evident from the above observations that we may consider the direction of the current in the light of a separate course; and by multiplying the rate of the current per hour by the number of hours it has been running, and treating this as a distance, we may estimate the ship's real place by any of the rules for compound courses.

Ex. 1.—A ship sailed N.N.E. at the rate of 8 knots an hour during 18 hours, in a current setting N.W. by W. $2\frac{1}{2}$ miles an hour; required the course and distance made good.

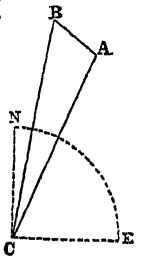

Fig. 42.

By Construction.—Draw the N.N.E., line CA (fig. 42) equal to $18 \times 8 = 144$ miles; and from A draw AB parallel to the N.W. by W. rhumb, and equal to $18 \times 2\frac{1}{2} = 45$ miles; now BC being joined will be the distance, and NCB the course. The first of these will measure 159 miles, and the second 6° 23′.

By Calculation—

The angle CAB	= 9 pts.		
CA	=144 m.		
AB	= 45 m.		
CA+AB	=189 m.		
CA−AB	= 99 m.		
Log. (CA−AB)	99 m.	=	1·995635
L cot ½CAB	4½ pts.	=	9·914173
			11·909808
Log. CA+CB	185 m.	=	−2·276462
L tan ½(ABC−ACB)	23° 15′	=	9·633346
½(ABC+ACB)	= 39 22		
∴ ACB=16° 7′ and ABC	= 62 37		
NCA	= 22 30		
∴ NCB the course	= 6 23		
Log. AB	45 m.	=	1·653212
L sin CAB	9 pts.	=	9·991574
			11·644786
L sin ACB	16° 7′	=	−9·443410
Log. BC	159 m.	=	2·201376

Or,

For first course we have course N.N.E., or 2 points.

And distance.....144 Whence, from traverse table,
True diff. latitude.....133·0 N. Departure.....55·1 E.

For second course we have course N.W. by W., or 5 points.

And distance.....45 And from traverse table,
True diff. latitude.....25 N. Departure.....37·4 W.

For last course—

True diff. latitude..... 158 N.
Departure..... 17·7 W.

Log. departure	17·7+10	=	11·24797
Log. true diff. latitude	158	=	−2·19866
L tan course	N. 6° 23′ E.	=	9·04931
L sec course	6° 23′−10	=	·00271
Log true diff. latitude	158 m.	=	2·19866
Log. distance	159	=	2·20137

Ex. 2.—A ship from Lat. 38° 20′ N. sailed 24 hours in a current setting N.W. by N., and by account is in latitude 38° 42′ N., having made 44 miles of easting; but the latitude by observation is 38° 58′ N.; required the course and distance made good, and the drift of the current.

Day's Work and Ship's Journal.

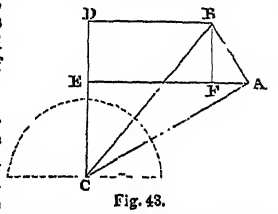

Fig. 43.

By Construction.—Make CE (fig. 43) equal to 22 miles, the difference of latitude by dead reckoning, and EA=44 miles, the departure, and join CA; make CD=38 miles, the difference of latitude by observation. Draw the parallel of latitude DB, and from A draw the N.W. by N. line AB, intersecting DB in B, and AB will be the drift of the current in 24 hours; CB being joined, will be the distance made good, and the angle DCB the true course. Now AB and CB applied to the scale will measure 19·2 and 50·5 respectively, and the angle DCB will be $41\frac{1}{4}$°.

By Calculation—

ABF..... = 3 pts.
BF=CD−CE..... = 16 miles.

To find AB.

Log. BF	16 m.	=	1·20412
L sec ABF	3 pts.	−10=	0·08015
Log. AB	19·2 m.	=	1·28427

Or drift of current..... 19·2 miles.

To find AF.

Log. BF	16 m.	=	1·20412
L tan ABF	3 pts.	−10=	9·82489
Log. AF	10·7 m.		1·02901

Hence BD=AE−AF=44−10·7=33·4.

To find the course.

Log. BD	33·4	+10=	11·52244
Log. CD	38	=	1·57978
L tan course	N. 41° 14′ E.	=	9·94266

To find the distance.

Log. sec course	41° 14′ E.	−10=	0·12376
Log. CD	38	=	1·57978
Log. distance	50·5 m.	=	·70354

By Traverse Table.—Taking the current course first, true difference of latitude 16, and course N.W. by N., we find in the traverse table the corresponding distance 19·3, and departure 10·7.

Again, for second course, we have true difference of latitude 38, and departure 44−10·7=33·3 E.

Points.	Course	Distance.	Diff. of Latitude.		Departure.	
			N.	S.	E.	W.
3	N.W. by N.	19·3	16	...	...	10·7
N. 41° E.	...	51	38	...	33·3	...

Whence the course and distance are found as above.

Or, from the traverse table to nearest degree and minute, we find in the columns of distance and angle, opposite to difference of latitude 38·5, and departure 35·5—distance 51, and angle 41°.

Chap. X.—OF THE DAY'S WORK AND SHIP'S JOURNAL.

The most usual application of the principles laid down in the preceding chapters, is to ascertain from the several courses and distances run by a ship in the interval between the noons of two successive days, the ship's place at the noon of the latter day,—*i.e.*, its latitude and longitude; its latitude and longitude being given for the noon of the preceding day. This constitutes a day's work; and the ship's place deduced therefrom is called her place by *account* or *dead reckoning*. The day aboard ship, like the astronomical day, commences at noon; and the ship's position is always calculated at every noon. In the Royal Navy, the log is hove once in every hour; but in most trading-vessels only once in every two hours. A record of the knots, and tenths of knots, run every hour or every two hours, the course, the direction of the wind, the leeway, and everything which affects the ship's place, is kept in the journal, which, for this purpose, is usually divided into six or seven columns. The first column on the left hand contains the hours

Day's Work and Ship's Journal.

from noon to noon; the second and third, the knots and tenths of knots sailed every hour, or every two hours; the fourth contains the courses steered; the fifth, the direction of the wind; and the sixth, when there are seven columns, contains the leeway; and the last contains general remarks, including phenomena, variation, &c., &c.

The mode of forming a table showing the deviation of the compass for the several positions of the ship's head, has already been given.

The courses steered, as entered in the log-book, must be corrected for variation, deviation, and leeway. The setting and drift of current, and the heave of the sea, are to be marked down. These are to be corrected for variation only. In the day's work, it is usual to treat a current as an independent course and distance. If the ship does not sail from a place whose latitude and longitude are known (which rarely happens), the bearing of some known place is to be observed, and its distance found, which is usually done by estimation. The ship is then supposed to have taken her departure from this place, in a course exactly opposite to the observed bearing, and to have run the estimated distance on it. If there be any reason to suspect the correctness of the estimated distance, it will be easy to obtain the true distance as follows:—Let the bearing be observed of the place from which the departure is to be taken; and the ship having run a certain distance on a direct course, the bearing of the same place is again to be observed. We shall then have a triangle, all of whose angles are known from the observed bearings, and one of its sides, viz., the distance the ship has sailed. The other two sides, viz., the distance of the ship from the place of departure at each of the observations, can be immediately found, as in problem 1 on "Oblique Sailing." The distances for each course may be obtained by adding together the hourly distances. The courses being thus corrected, and the distances found, the latitude and longitude in may be found by any of the methods explained in chap. iv. As the differences of latitude are not usually great, the traverse table may generally be made use of for finding the latitude in; and having found the middle latitude, the longitude may be obtained by the middle latitude method.

The following example will enable the reader to apply the directions we have just given:—

Ex.—September 12, 1857, at noon, a point of land in Lat. 64° 20′ S., and Long. 59° 40′ E., bore by compass S.E., distant 15 miles (ship's head being E.), afterwards sailed as by the following log-account; find the latitude and longitude in, on September 13, at noon.

H.	K.	Tenths.	Course.	Wind.	Leeway.	Remarks.
1	4	7	W. by N.	N.E.	2	P.M.
2	6	4	...	...	...	
3	5	8	...	...	...	
4	4	...	...	...	...	Variation of the compass, 1½ W.
5	7	...	...	...	...	
6	6	5	...	...	...	
7	7	4	...	...	...	
8	4	4	...	...	...	(For deviation see the table, page 13.)
9	5	6	N.N.E.	N.W.	1¼	
10	6	...	...	...	...	
11	5	5	...	...	...	
12	6	...	...	...	...	
1	7	4	...	...	...	A.M.
2	4	2	...	...	...	
3	6	...	S.E.	E.N.E.	2½	During the last 7 hours a current set the ship N.W. at the rate of two knots an hour.
4	5	5	...	...	...	
5	4	...	...	...	...	
6	6	...	...	...	...	
7	4	4	...	...	...	
8	5	5	...	...	...	
9	3	8	S. by W.	W.	2½	
10	4	5	...	...	...	
11	7	...	...	...	...	
12	5	5	...	...	...	

Day's Work and Ship's Journal.

Departure course, N.W. being the opposite to S.E.

Compass course	4 pts.	0 qrs.	left of N.
Variation	1	2	„
Deviation	0	3	right, or
True course	4	3	N.W.¾W.
Dist.	15.		

First course, W. by N.

Compass course	7 pts.	0 qrs.	left of N.
Variation	1	2	„
Deviation	0	3	„
Leeway (wind N.E. on starboard tack)	2	0	„
	11	1	left of N.
Or true course	4	3	right of S., or
Dist.	46·2		S.W.¾W.

Second course, N.N.E.

Compass course	2 pts.	0 qrs.	right of N.
Variation	1	2	left.
Deviation	0	3	right.
Leeway (wind N.W. on port tack)	1	3	right.
True course	3	0	right of N., or
Dist.	34·7.		N.E. by N.

Third course, S.E.

Compass course	4 pts.	0 qrs.	left of S.
Variation	1	2	left.
Deviation	0	1	right.
Leeway (wind E.N.E. on port tack)	2	1	„
True course	3	0	left of S. or
Dist.	31·4.		S.E. by S.

Fourth course, S. by W.

Compass course	1 pt.	0 qrs.	right of S.
Variation	1	2	left.
Deviation	0	2	„
Leeway (wind W. starboard tack)	2	2	left.
True course	3	2	left of S., or
Dist.	20·8.		S.E. by S.½E.

Current N.W.

Compass course	4 pts.	0 qrs.	left of N.
Variation	1	2	„
Deviation	0	0	„
	5	2	left of N. or
Dist.	14.		N.W. by W.½W.

Enter these in a table as under:—

Points.	Course.	Dist. Table.	Diff. Lat. N.	Diff. Lat. S.	Departure. E.	Departure. W.
4½	N.W.¾W.	15	8·9	...	...	12·0
4½	S.W.¾W.	46·2	...	27·4	...	36·9
3	N.E.6N.	34·7	29·1	...	19·4	...
3	S.E.6S.	31·4	...	25·8	17·2	...
3½	S.E. by S.½E.	20·8	...	16·2	13·3	...
5½	N.W. by W.½N.	14	6·6	...	...	12·3
			44·6	68·4	49·9	61·2
				44·6	...	49·9
				True diff. lat. S. 23·8	Dep. W. 11·3	

Lat. from	64° 20′ S.	Lat. from	64° 20′ S.
T. D. Lat.	0 23 S.	Half	0 12 S.
Lat. in	64 43 S.	Mid. Lat.	64 32 S.
Log. departure	11·3	=	1·05308
L sec mid. lat	64° 32′ −10	=	0·36654
Log. diff. long.	26·2	=	1·41962

Long. from	59° 40′ E.	
Diff. long.	0 26 W.	
Long. in	59 14 E.	

In this example the true differences of latitude and departures are taken by inspection from the traverse table.

When a ship is bound for a distant port, the bearing and distance of the port must be found. This may be done by calculation or by a chart. If islands, capes, or headlands intervene, it will be necessary to find the several courses and distances between each successively. The true course between the places must be reduced to the compass course

Sea Charts. by making the requisite allowances for variation and deviation, as already explained.

In hard blowing weather, with a contrary wind and a high sea, it is impossible to gain any advantage by sailing. In such cases, therefore, the object is to avoid as much as possible being driven back. With this intention it is usual to lie to under no more sail than is sufficient to prevent the violent rolling to which the vessel would be otherwise subjected, to the endangering of her masts and straining her timbers, &c. When a ship is brought to, the tiller or wheel is put down over to the leeward, which brings her head round to the wind. The wind having then little power over the sails, the ship loses her way through the water; and the action of the water on the rudder ceasing, her head falls off from the wind, the sail which she has set fills, and gives her fresh way through the water, which, acting on the rudder, brings her head again to the wind. Thus the ship has a kind of oscillating motion, coming up to the wind and falling off from it again alternately. The middle point between those upon which she comes up and falls off is taken for her apparent course; and the leeway, variation, and deviation are to be allowed from this to find the true course.

It is generally found that the latitude by account does not agree with that by observation. On considering the imperfections of the common log-line, and the uncertainty with regard to variation, an exact agreement of latitudes cannot be expected. When the difference of longitude is to be found by dead reckoning, and the latitudes by account and observation disagree, several writers on navigation have proposed to apply a conjectural correction to the departure or difference of longitude. Thus, if the course is near the meridian, the error is wholly attributed to the distance, and the departure is to be increased or diminished accordingly; if near the parallel, the course only is supposed to be erroneous; and if the course is towards the middle of the quadrant, the course and distance are both assumed to be in error. This last correction will, according to different authors, place the ship upon opposite sides of her meridian by account. As these corrections, therefore, are no better than guessing, they should be absolutely rejected.

If the latitudes do not agree, the navigator should examine his log-line and half-minute glass, and correct the distance accordingly. He is then to consider if the variation and leeway have been properly ascertained; if not, the courses are to be again corrected, and no other alteration whatever is to be made in them. He is next to observe if the ship's place has been affected by a current or heave of the sea, and to allow for them according to the best of his judgment. By applying these corrections, the latitudes will generally be found to agree tolerably well; and the longitude may be corrected in the same way.

It will be proper for the navigator to determine the longitude of the ship by observation as often as possible, and the reckoning is to be carried forward in the usual manner from the last good observation; yet it will perhaps be very satisfactory to keep a separate account of the longitude by dead reckoning. The modes of finding the latitude and longitude of a ship by observation, and the variation of the compass, will be given in the next book.

Chap. XI.—OF SEA CHARTS.

The charts usually employed in the practice of navigation are the *Plane* and *Mercator's charts*. The former of these is adapted to represent a portion of the earth's surface near the equator, where the change in the lengths of corresponding arcs of the parallel is very small; and the other for all portions of the earth's surface. (For a particular description of these, see the articles Chart and Geography.) We shall here only describe their use.

Use of the Plane Chart.

Sea Charts.

Prob. I.—To find the latitude and longitude of a place on the chart.

Rule.—Take the least distance of the given place from the nearest parallel of latitude; this distance applied to the graduated meridian from the extremity of the parallel will give the latitude of the place. In the same way the longitude is found by taking the least distance from the nearest meridian, and applying it to the graduated parallel.

Thus the distance between Bonavista and the parallel of 15° being laid from that parallel on the graduated meridian, will reach to 16° 5′, the latitude required.

Prob. II.—To find the course and distance between two given places on the chart.

Rule.—Lay a ruler over the given places; if a parallel ruler be used, keeping the edge of one ruler passing through the places fixed, move the other until it passes through the centre of one of the compasses on the chart; the point of the compass through which this edge passes will show the course.

Or, generally, let a line on the edge of another ruler be placed so as to be parallel to the first ruler, and to pass through the centre of a compass; it will cut the circumference in a point which will determine the course.

The interval between the places being applied to the scale will give the distance.

Thus the course from Palmas to St Vincent will be found to be about S.S.W.$\frac{3}{4}$W., and the distance 13$\frac{1}{4}$° or 795 miles.

Prob. III.—The course and distance sailed from a known place being given, to find the ship's place on the chart.

Rule.—Lay a ruler over the given place parallel to another ruler laid over one of the compasses, with one edge passing through the centre, and the other the point on the circumference which shows the course, and lay off on it the distance taken from the scale; it will give the point representing the ship's present place.

Thus, supposing a ship has sailed S.W. by W. 160 miles from Cape Palmas; then by proceeding as above, it will be found that she is in Lat. 2° 57′ N.

The reader will have no difficulty in solving various other problems by means of this chart, being, in fact, only the construction of the various problems in plane sailing on this chart.

Use of Mercator's Chart.

The method of finding the latitude and longitude of a place, and the course or bearing between two given places, is the same as in the plane chart, which see.

Prob. I.—To find the distance between two given places on the chart.

Case 1.—When the given places are under the same meridian.

Rule.—The difference or sum of their latitudes, according as they are on the same or on opposite sides of the equator, will be the distance required.

Case 2.—When the given places are under the same parallel.

Rule.—If that parallel be the equator, the difference or sum of their longitudes, according as they are on the same or on opposite sides of the first meridian, is the distance; otherwise take the distance between the places, lay it off upwards and downwards from the given parallel, and the intercepted degrees will be the distance between the places.

Or take an equal extent of a few degrees on the meridian on each side of the parallel; and the number of extents and parts of an extent contained between the places, multiplied by the length of an extent, will give the required distance.

Observation Instruments.

Case 3.—When the given places differ both in latitude and longitude.

Rule.—Find the difference of latitude between the given places, and take it from the equator or graduated parallel; then lay a ruler over the places, and move one point of the compass opened to the difference of latitude just found along the edge of the ruler till the other just touches a parallel; then the distance from the point of the compass on the ruler to the point of intersection of the ruler and the parallel, applied to the equator, will give the distance between the places in degrees and parts of a degree, which, multiplied by 60, will give it in miles.

Prob. II.—Given the latitude and longitude in; to find the ship's place by the chart.

Rule.—Lay a ruler over the given latitude, and lay off the given longitude from the first meridian by the edge of the ruler, and the ship's present place will be obtained.

Prob. III.—Given the course sailed from the given place, and the latitude in; to find the ship's present place on the chart.

Rule.—Lay a ruler over the place sailed from, in the direction of the given course; its intersection with the parallel of latitude in, will give the ship's present place.

Prob. IV.—Given the latitude and longitude of the place left, and the course and distance sailed; to find the ship's present place on the chart.

Rule.—Lay a ruler over the given place, in the direction of the given course, take the distance sailed from the equator, and put one point of the compass opened to this distance at the intersection of the ruler with any parallel, and the other point will reach to a certain place by the edge of the ruler. This point being kept fixed, draw in the other point of the compass until it just touch the above parallel when swept round; apply this extent to the equator, and it will give the difference of latitude. Hence the latitude in is known; and the intersection of the edge of the ruler with the parallel of this latitude will give the ship's present place.

The above problems sufficiently illustrate the use of Mercator's Chart. The reader will have no difficulty in solving other problems by means of it.

BOOK II.

CONTAINING THE METHODS OF FINDING THE LATITUDE AND LONGITUDE OF THE SHIP AT SEA, THE VARIATION OF THE COMPASS, AND TIME OF HIGH WATER.

Chap. I.—DESCRIPTION AND USE OF INSTRUMENTS USED IN OBSERVATIONS.

SECT. I.—OF HADLEY'S SEXTANT AND QUADRANT.

The principal difference between these instruments is in the extent of the angle which can be observed by them; and in the more elaborate and careful workmanship of the latter of the two. Indeed the quadrant is only available for taking observations which determine the latitude. The distances of the moon from the sun or other heavenly body, which are frequently used for the determination of the longitude, can only be observed by the help of the sextant.

Allowing for these differences, the *principle* on which the quadrant and sextant are constructed is the same. In the Royal Navy sextants are almost exclusively in use, although quadrants are still employed for the observation of altitudes in many trading vessels. The sextant, therefore, will first be described, and afterwards those points in which the quadrant differs from the sextant will be explained.

The reader is supposed to be aware of the ordinary laws with regard to the propagation and reflection of light, viz.,—that in the same medium, light is propagated in straight lines, the smallest conceivable quantity of which that can be stopped or propagated alone is called a ray; and that when a ray of light is incident on a plane reflecting surface, it is bent or reflected after incidence in such manner, that the incident and reflected rays and the straight line perpendicular to the mirror at the point of incidence (called the normal to the surface) lie all in one plane; and that the incident and reflected rays make equal angles with the normal or the surface.

Observation Instruments.

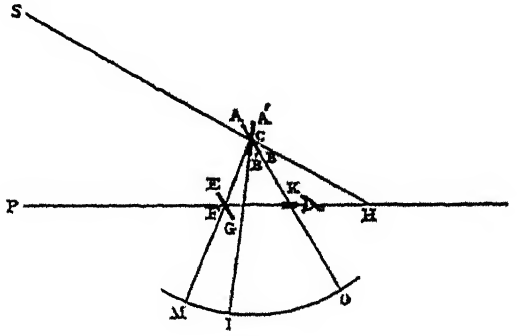

Fig. 44.

Let MO (fig. 44) be an arc of a circle, CO and CM two radii, and CI be a moveable radius carrying a plane mirror, silvered through its whole extent, firmly fixed to it; EFG another mirror, the lower part of which FG only is silvered, while the upper part EF is unsilvered, so that a ray reflected from the lower portion FG in direction FH, and a direct ray PFH through the unsilvered part EF, may be seen together by an eye at K. This mirror is fixed to the radius CM in such a manner that when the moveable radius occupies the position ACO, the two mirrors ACB and EFG are both perpendicular to the plane of the instrument, and parallel to one another.

Let now S and P be two distant objects whose angular distance is required to be found. Let the instrument be placed so that its plane passes through S and P, and that a ray from P, passing through the unsilvered glass EF, may be seen directly by an eye at K; and while in this position let the bar be moved round C, CI carrying the mirror with it until a ray from S, falling on ACB, is reflected in the direction CF, and again reflected by FG in the direction FH; so that to the eye at K the images of the two objects S and P are seen together, or coincide.

Produce SA to meet PFH in H; then SHP is the angle through which the ray SA has been deflected, and is also the angular distance between S and P. Let A'B' be the new position of the mirror AB; then ACA' is the angle through which the mirror has turned, and consequently also the angle through which CI has moved.

Now angle of deflection

$$SHP = SCF - CFH$$
$$= 180° - 2\,FCB' - (180° - 2\,EFC)$$

because by law of reflection,

$$SCA' = FCB'; \text{ and therefore}$$
$$SCF = 180° - SCA' - FCB'$$
$$= 180° - 2\,FCB',$$

and $EFC = GFH$; and therefore

$$CFH = 180° - EFC - GFH$$
$$= 180° - 2\,EFC;$$

$\therefore SHP = 2\,EFC - 2\,FCB'.$

But $EFC = FCB$, because EFG is parallel to ACB;

or $SHP = 2\,FCB - 2\,FCB' = 2\,ACA'$

= twice the angle through which CI has moved.

Hence if the arc OM be divided into degrees, and each degree marked as two degrees, the reading off of the arc OI will be the angle between the distant objects S and P.

Observation Instruments.

An instrument constructed on this principle, whose circular arc or limb is a sixth part of a circle, and therefore capable of measuring angles up to 120°, is called a sextant; if the limb contain only an eighth part of a circle, it is a quadrant, and can only measure angles up to 90°.

The Sextant.

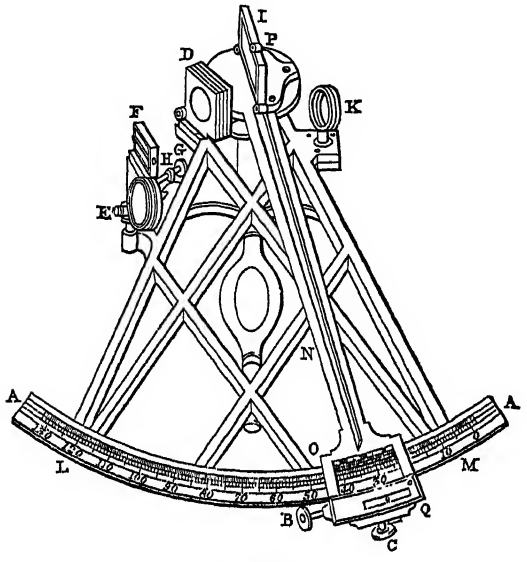

Fig. 45.

(1.) PLM (fig. 45) is the frame of the sextant.
(2.) AA the graduated arc or limb.
(3.) N the index, carrying the vernier OQ.
(4.) I the index-glass.
(5.) F the horizon-glass.
(6.) D the coloured or dark glasses between the index-glass and horizon-glass.
(7.) E the coloured glasses behind the horizon-glass.
(8.) K the tube or collar in which the telescope is inserted.

The frame of the sextant.

The frame of the sextant consists of an arc AA, firmly attached to the two radii LP, MP, which are bound together by braces, as shown in the figure, to prevent warping and liability to bend.

The index.

The index N is a flat bar of brass, and turns on the centre of the sextant; at the lower end of the index there is an oblong opening; to one side of this opening the vernier scale is attached to subdivide the divisions of the arc; at the end of the index there is a piece of brass which bends under the arc, carrying a spring to make the vernier scale lie close to the divisions. It is furnished with a finger-screw C, by which the index is fixed in any position to the limb of the instrument. There is also an adjusting-screw B attached to the index, capable of moving it with greater accuracy than the hand; this screw does not act until the index is fixed by the finger-screw C. Care must be taken not to force the adjusting-screw when it arrives at either extremity of its adjustment. When any considerable movement is required to be given to the index, the screw C at the back of the sextant must be set free; but where the index is brought nearly to the divisions required, this back screw should be tightened, and then the index gradually moved by the adjusting-screw.

The index-glass.

Upon the index, and near its axis of motion, is fixed a plane speculum or mirror of glass I, quicksilvered. It is set in a brass frame, which is firmly fixed by a strong cock to the centre plate of the index, with its face perpendicular to the plane of the instrument. This mirror being fixed to the index, moves along with it, and has its direction changed by the motion thereof. As has already been observed, this glass is to receive the rays from the sun or other object, and reflect them upon the horizon-glass. It is furnished with screws at its back, the object of which is to replace it in a perpendicular position, if by any accident it has been deranged.

Observation Instruments.

The horizon-glass.

To the radius PL is attached a small speculum F, whose surface is parallel to the index-glass when zero on the index coincides with zero on the limb. The under part only of this speculum is silvered, the upper half being left transparent, and the back part of the frame cut away, that nothing may impede the sight through the unsilvered part of the glass. The edge of the foil of this glass is nearly parallel to the plane of the instrument, and ought to be very sharp, and without a flaw. It is set in a brass frame, which turns on axes and pivots which move in an exterior frame; the holes in which the pivots move may be tightened by four screws in the exterior frame. G is a screw by which the horizon-glass may be set perpendicular to the plane of the instrument. Should this screw become loose, or move too easy, it may be easily tightened by turning the capstan-headed screw H which is on one side of the socket through which the stem of the finger-screw passes; this screw G is in some instruments under the glass, in others behind it, and in others at the side.

The coloured glasses D and E.

There are four coloured glasses at D, tinged red and green, each of which is set on a separate frame that turns on a centre. They are used to defend the eye from the brightness of the solar image and the glare of the moon, and may be used separately or together as occasion may require. There are three more such glases placed behind the horizon-glass at E, to weaken the rays of the sun or moon when viewed directly through the horizon-glass. The paler glass is sometimes used in observing altitudes at sea to take off the strong glare of the horizon.

The telescopes.

The sextant is furnished with a plane tube K; and in order to render objects distinct, it has two telescopes—one a Galileo's telescope, representing the objects erect in their natural position; the longer one, an astronomical telescope, shews them inverted. It has a large field of view; and has parallel wires placed in the principal focus, where a true image of the object viewed by it is seen; thus rendering the position of the image more exact and more easy to be read off, and is that which should be used in taking observations at sea when great accuracy is required. A little use will soon accustom the observer to the inverted position, and to manage the instrument with ease. By a telescope the contact of the images is more perfectly distinguished; and by the place of the images in the field of view, it is easy to perceive whether the sextant is held in the proper position for observation. By sliding the tube that contains the eye-glasses in the inside of the other tube, the object is suited to different eyes, and made to appear perfectly distinct and well-defined.

The telescopes are to be screwed into a circular ring at K; this ring rests on two points against an exterior ring, and is held to it by two screws; by turning one of these screws, and tightening the other, the axis of the telescope may be set parallel to the plane of the sextant. The exterior ring is fixed on a triangular brass stem which slides in a socket, and, by means of a screw at the back of the sextant, may be raised or lowered so as to move the centre of the telescope to that part of the horizon-glass which shall be deemed most fit for observation. Tinged glasses are provided to screw on the eye-end of either of the telescopes or the plane tube.

Reading off divisions on the limb.

The limb of the sextant is divided from right to left into 120 primary divisions, which are to be considered as degrees; the degree is subdivided in some cases into two equal parts, each of which is 30′; in others into three equal parts, each of which is 20′; and in others again into six equal parts, each of which is 10′. If the zero of the index stand exactly at one of the divisions of the limb, the

Observation Instruments.

reading off in that case is immediately known. If, however, the zero of the index do not stand exactly at one of the divisions, but distant from it by a small space, the value of this space is known by means of the divisions of the vernier-plate to the left of 0.

Reading off divisions on the vernier.

The vernier contains a space equal to nineteen divisions of the limb, and is divided into twenty equal parts; hence the difference between a division on the vernier and a division on the limb is one-twentieth of a division of the limb, or 1′, if the interval between divisions on the limb is equal to 20′. Or supposing the limb divided into intervals of 10′, and that fifty-nine divisions of the limb correspond to sixty divisions of the vernier; it is then evident that the difference between a division of the instrument and of the vernier is $\frac{1}{60}$th part of 10′, *i.e.*, 10″. This is the most usual kind of division.

To find the actual reading off in any particular case, we must observe which division of the vernier coincides with a division of the limb; the number denoting this, multiplied by the value of the difference between a division of the limb and of the vernier, will give the additional reading. Suppose, for instance, the nearest division of the limb to the zero of the vernier to be 25° 30′, and the eighth division of the vernier to be coincident with a division of the limb, the additional angle will be 80″ or 1′ 20″, and the reading off will be 25° 31′ 20″.

Adjustments of the sextant.

The adjustments of the sextant are to set the mirrors perpendicular to the plane of the instrument, and parallel to one another when the index is at zero; and to set the axis of the telescope parallel to the plane of the instrument.

Adjustment 1.—To set the index-glass perpendicular to the plane of the sextant.

Set the index towards the middle of the limb, and hold the sextant so that its plane is nearly parallel to the horizon; then look into the index-glass, and if the portion of the limb seen by reflection appears in the same plane with the limb seen directly, the speculum is perpendicular to the plane of the instrument. If they do not appear in the same plane, *i.e.*, if the image be seen above or below the arc itself, its position must be gradually and carefully changed by means of the screws at its back until the error is rectified.

Adjustment 2.—To set the horizon-glass perpendicular to the plane of the instrument.

Place the instrument horizontal, and direct the sight to a distant well-defined object, as the sun, so as to view it directly; then move the index until the image of the object seen by reflection is on the field of view, and move the index backwards and forwards so as to make the image pass over the object. If it pass exactly over the object, the fixed mirror is perpendicular to the plane of the instrument; if not, move the screw G until their exact coincidence takes place.

Adjustment 3.—To set the horizon-glass parallel to the index-glass when the zero of the index or vernier-plate coincides with the zero of the graduations of the limb.

Set 0 on the index exactly to 0 on the limb, and fix it in that position by the screw on the under side of it; hold the sextant with its plane vertical, and direct the sight to a well-defined part of the horizon; then if the horizon seen on the silvered part coincides with that seen through the transparent part, the horizon-glass is adjusted; but if the horizons do not coincide, the position of the glass must be altered by moving a screw placed near the fixed reflector, which gives it a motion about an axis perpendicular to the plane of the instrument.

This adjustment is seldom made, as turning the adjusting-screw too often renders this part of the instrument very apt to get out of order. It is usual, therefore, to determine the *error* in the reading called the *Index Error*.

To do this, direct the sight to the horizon, and move the index until the reflected horizon coincides with that seen by direct vision; then the difference between 0 on the limb and 0 on the vernier-plate will be the *index error*, which is to be added when 0 of the vernier is to the right of 0 on the limb; otherwise subtracted.

Observation Instruments.

A more accurate method than the above is to measure the sun's apparent diameter twice with the index placed alternately on the right and on the left of the zero point of the graduated limb. Half the difference of these two measures will be the index error, which must be added to, or subtracted from, all observations, according as the diameter measured with the index to the left of 0 is less or greater than the diameter measured with the index to the right of the beginning of the divisions. Care must be taken to measure the sun's horizontal diameter, as the vertical diameter is often affected with refraction. This must be done by keeping the plane of the instrument at right-angles to the vertical diameter of the sun.

For example, on January 2, 1857, the sun's diameter, measured with the index first to the right and secondly to the left of the zero point of division, was 33′ and 32′ 20″ respectively, and the index error obtained by taking the semidifference is − 20″.

Adjustment 4.—To set the axis of the telescope parallel to the plane of the instrument.

Turn the eye-end of the telescope until the two wires are parallel to the plane of the instrument; and let two distant objects, or two stars of the first magnitude, be selected, whose distance is not less than 90° or 100°; make the contact of these as perfect as possible at the wire nearest the plane of the instrument; fix the index in this position; move the sextant until the objects are seen at the other wire, and if the same points are in contact, the axis of the telescope is parallel to the plane of the sextant. If, however, the objects are apparently separated, or overlap one another, correct half the error by the screws in the circular part of the supporter, one of which is above, and the other between the telescope and sextant; turn the adjusting-screw at the end of the index till the limbs are in contact; then bring the objects to the wire next the instrument, and if the limbs are in contact, the axis of the telescope is adjusted; if not, proceed as at the other wire, and continue till no error remains. In practice, this adjustment is usually made by means of the sun and moon. The mode of bringing the limbs of the sun and moon into contact will be explained when the use of the sextant is treated of. It is sometimes necessary to know the angular distance between the wires of the telescope; to find which, place the wires perpendicular to the plane of the sextant, hold the instrument vertical, direct the sight to the horizon, and move the sextant in its own plane till the horizon and upper wire coincide; keep the sextant in this position, and move the index till the reflected horizon is covered by the lower wire, and the difference of readings off in these two positions will be the angular distance between the wires. Other and better methods will readily occur to the observer on land.

The Quadrant.

It has been already observed, that this instrument differs from a sextant in the extent of the divided limb and in its rougher manufacture. It is only calculated for observing altitudes. Fig. 46 represents a quadrant of the common construction.

The frame, index, index-glass, and F the fore horizon-glass, are much the same as in the sextant. There is, besides, another horizon-glass G, called the *back* horizon-glass attached to the same radius as F. Instead of a tube or telescope, the quadrant is furnished with vanes or sights H and I. There are but three coloured glasses, two of which are red and the other green. They are fixed at K, as shown in the figure, when the fore horizon-glass is used.

Observation Instruments.

If the back horizon-glass be used, they are transferred to N. The back horizon-glass is silvered at both ends, but has a

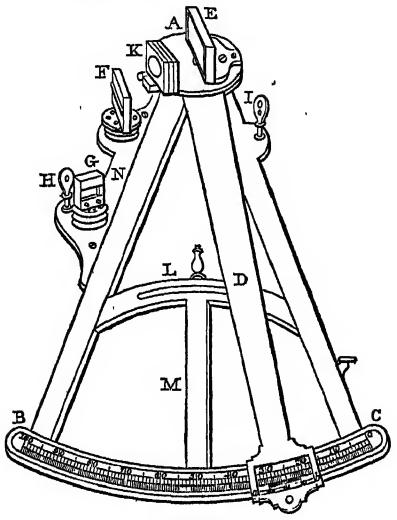

Fig. 46.

transparent slit in the middle through which the horizon may be seen. Each of the horizon-glasses is set in a brass frame, to which there is an axis passing through the wood-work, and is fitted to a lever on the under side of the quadrant, by which the glass may be turned a few degrees on its axis, in order to set it parallel or perpendicular, according as it is the fore or back horizon-glass, to the index-glass. The lever has a contrivance to turn it slowly, and a button to fix it. To set the glasses perpendicular to the plane of the instrument, there are two sunk screws, one before and the other behind each glass; these screws pass through the plate on which the frame is fixed into another plate; so that by loosening one and tightening the other of these screws, the direction of the frame, with its mirror, may be altered, and set perpendicular to the plane of the instrument.

The sight-vanes H and I are perforated pieces of brass, designed to direct the sight parallel to the plane of the quadrant. The vane I has two holes, one exactly at the height of the silvered part of the horizon-glass, the other a little higher, to direct the sight to the middle of the transparent part of the mirror.

The limb is divided into ninety primary divisions, which are considered as degrees, and each degree subdivided into three equal parts, which are therefore of 20′ each. The vernier-plate is generally so divided as to enable the observer to read off accurately to minutes.

Adjustments of Hadley's quadrant.

These consist in setting the mirrors perpendicular to the plane of the instrument, and the fore horizon-glass parallel, and the back horizon-glass perpendicular to the index-glass, when the zero of the index or vernier-plate coincides with zero of the graduations on the limb.

The adjustments for the index-glass and fore horizon-glass are performed nearly in the same way as for the sextant. The index error, however, must be ascertained by bringing the horizon by reflection into the same line with the horizon seen directly. The method by taking the distance of two stars of the first magnitude, or the sun and moon, is inapplicable here.

The back horizon-glass is so seldom used, that for its adjustments and the mode of taking observations with it, the reader is referred to Norie's *Navigation*, and other works in which this subject is treated.

Use of Hadley's sextant and quadrant.

The altitude of an object may be determined by either instrument, and is the reading off on the limb, with the proper index error applied, when by reflection that object appears to be in contact with the horizon. The distance between the sun and moon, or other heavenly bodies, may be observed by the sextant when the limbs of the bodies whose distance is required appear to be in contact. If the quadrant be used for taking the altitude of the sun, when it is so bright that its image may be seen in the transparent part of the fore horizon-glass, the eye is to be applied to the upper hole in the sight-vane, otherwise to the lower hole; and in this case the quadrant is to be held so that the sun be bisected by the line of separation of the silvered and transparent parts of the glass. The moon is to be kept as nearly as possible in the same position, and the image of the star is to be observed on the silvered part of the glass adjacent to the line of separation of the two parts.

Observation Instruments.

With the quadrant two different methods of taking observations may be employed. In the first, the observer faces the sun, and looks to that part of the horizon which is immediately under the sun, and the observation is therefore called the *fore observation*. In the other method, the observer's back is towards the sun, and he looks to the part of the horizon opposite to that which is under the sun; and this is consequently called the *back observation*. It is not to be employed except when the horizon under the sun is obscured, or rendered indistinct by fog or other impediment.

In all cases of taking altitudes, it must be considered that it is necessary to be quite sure that the distance of the sun or other body from the horizon is the least possible, otherwise it would not be the altitude that is observed. Consequently, after the instrument has been placed as nearly as possible in a vertical position, and a contact made, a motion about the line of sight of the sun must be communicated to the instrument, so as to keep the image always in the same part of the silvered mirror, the plane of the instrument being inclined. In this way we keep the angular distance of the sun from the line through the eye by which it is viewed the same, and the sun's image describes a small circle, whose angular radius is this distance. The horizon being fixed and viewed directly, will always occupy the same position. If, then, on giving this vibratory motion to the instrument, the arc described by the sun touches the horizon, the angular distance observed is the altitude. If it should cut the horizon, so that a portion of the sun's image goes below it, the index must be moved back until this arc simply touches the horizon. In the back observation with the quadrant, and in observing with the sextant furnished with the inverting telescope, the images are inverted, and the arc described by the sun's image lies below the horizon, to which line it is convex.

The motion must be given round the axis passing through the observer's eye and the sun. To do this, a motion about the axis of vision must be given to the instrument, and at the same time the observer must turn himself about upon his heel; for the motion about the line of sight of the sun may be resolved into these two motions; and the observer has no means of giving the requisite motion directly by one movement. When the sun is near the horizon, the line from the eye to the sun will not be far removed from the axis of vision, and the principal motion of the instrument will be performed on this axis; while that part of the motion made about the vertical axis will be small. On the contrary, if the sun be near the zenith, the line from the eye to the sun is nearly vertical and perpendicular to the axis of vision; hence the motion about the vertical axis is the greatest, and that about the axis of vision very trifling. In intermediate positions of the sun the motions of the instrument about these two axes will be more equally divided. When the distance between the moon and sun, a planet or a star, is to be observed, the sextant must be so held that its plane may pass through the eye of the observer and both objects; and the reflected image of the brighter of the two is to be brought into contact with the other seen directly. To effect this, therefore, it is evident that when the brighter object is to the right of the other, the face of the sextant

Observation Instruments.

must be held upwards, and if to the left, downwards. When the face of the sextant is held upwards, the instrument should be supported with the right hand, and the index moved with the left hand. But when the face of the sextant is from the observer, it should be held with the left hand, and the motion of the index regulated with the right hand. Sometimes a sitting posture will be found convenient for the observer, particularly when the reflected object is to the right of the direct one. In this case the instrument is supported by the right hand; the elbow may rest on the right knee; the right leg at the same time resting on the left knee. If the sextant be provided with a ball and socket, and a staff, one of whose ends is attached thereto, and the other rests in a belt fastened round the observer's body, the greater part of the weight of the instrument will be supported by his body. In all cases where the sextant is used, when the contact is nearly made, the index should be fixed by the under screw, and the remaining small motion given by the adjusting screw.

Causes of error in the use of sextant or quadrant.

Error may arise from two kinds of causes: one inherent in the construction of the instrument—as defect of parallelism or perfect planeness in the fore and back surfaces of the mirrors, as also of the coloured glasses, and of the true circular form of the arc, and true centring, for which no remedy can be provided; and the other arising from the bending and elasticity of the index or moveable radius.

The parallelism of the two surfaces of the mirrors may be tested by viewing through them obliquely a distant distinct object. If the image is perfect and well defined, the surfaces are parallel; otherwise not.

To ascertain whether the surfaces of the mirrors are plane, observe the angle between two distant objects which are nearly of the same altitude, the image of the left-hand object being brought into contact with the right-hand object viewed directly; then move the instrument *in its own plane* so as to bring the image of the right-hand object into contact with the left-hand object viewed directly. If they continue in contact, the surfaces are plane; otherwise not.

To test the form of the dark glasses, measure the sun's diameter to the right and to the left of the zero point with different combinations of the glasses. If the sum of the diameters so measured be nearly equal to four times the semidiameter given in the *Nautical Almanac*, the form of the glasses is satisfactory. For the true centering of the arc, and its truly circular form and correct graduation, the navigator must trust entirely to the skill of the maker.

By reason of the bending and elasticity of the index, and the resistance it meets with in turning round the centre, its extremity, on being pushed round the arc, will sensibly advance before the index-glass begins to move, and may be seen to recoil when the force acting on it is removed. Mr Hadley, in order to remedy this defect, which he seems to have apprehended, gave special directions that the index be made broad at the end next the centre, and the centre or axis itself have as easy a motion as is consistent with steadiness; that is, an entire freedom from looseness or *shake*, as the workmen term it. By strictly complying with these directions, the error in question may indeed be greatly diminished, so as to be nearly insensible, when the index is made strong, and the proper medium between the two extremes of a shake at the centre on the one hand, and too much stiffness there on the other, is nicely hit; but it cannot be entirely corrected, for to more or less of bending the index will always be subject, and some degree of resistance will remain at the centre, unless the friction there could be totally removed, which is impossible.

Of the reality of the error to which he is liable from this cause, the observer, if he is provided with an instrument furnished with an adjusting screw for the index, may thus satisfy himself:—After finishing the observation, lay the instrument on a table, and note the angle; then cautiously loosen the screw which fastens the index, and it will immediately, if the instrument is not remarkably well constructed, be seen to start from its former situation, more or less according to the perfection of the joint and strength of the index. This starting, which is due to the index recoiling after being released from the confined state it was in during the observation, will sometimes amount to several minutes; and its direction will be opposite to that in which the index was moved by the screw at the time of finishing the observation. But how far it affects the truth of the observation depends on the manner in which the index was moved in setting it to 0, for adjusting the instrument, or in finishing the observations necessary for finding the index error.

Observation instruments.

The easiest and best rule to avoid these errors seems to be this:—In all observations made by Hadley's quadrant or sextant, let the observer take notice constantly to finish his observations by moving the index in the same direction which was used in setting it to 0 for adjusting, or in the observations necessary for finding the index error. If this rule is observed, the error arising from the spring of the index will be obviated. For as the index was bent the same way, and in the same degree, in adjusting as in observing, the truth of the observations will not be affected by this bending.

To Observe the Sun's Altitude at Sea.

Turn down one of the dark glasses before the horizon-glass (if the instrument be the quadrant, the fore horizon-glass is to be used) according to the sun's brightness; direct the sight to that part of the horizon which is under the sun, and move the index until the coloured image of the sun appears in the horizon-glass. Then give the instrument a slow vibratory motion about the axis of vision, as already described; move the index until the upper or lower limb of the sun is nearly in contact with the horizon at the lowest or highest part of the arc (according as the image is seen erect or inverted) described by this motion; and complete the contact by the tangent-screw, if the sextant be used—if not, by moving the index. The reading off of the limb will be the altitude of the sun.

To Observe the Moon's Altitude at Sea.

Turn down the green glass, and observe the moon in the silvered part of the horizon-glass, the eye being directed towards the horizon; move the index gradually, and proceed as already described in the case of the sun, until the enlightened limb is in contact with the horizon at the lowest or highest point of the arc described by the vibratory motion. The reading off will be the altitude of the moon's observed limb. If the lower limb be observed, the moon's semidiameter must be added; and if the upper limb be observed, it must be subtracted from the observed altitude, in order to obtain the altitude of the moon's centre. If the observation is made in the day-time, the coloured glass is not to be used.

To Observe the Altitude of a Star or Planet.

Put the index to zero; then direct the sight to the star so as to see it through the unsilvered part of the horizon-glass; turn the instrument a little to the left, and the image of the star will be seen in the silvered part of the glass. Now move the index, and the image will be seen to descend; continue to move the index gradually, until the star is in contact with the horizon at the lowest point of the arc described by the vibratory motion; in the case of the sextant, clamping the index when the contact is nearly made, and completing it with the adjusting or tangent screw.

Observation Instruments.

To find the Altitude of the Sun on Shore with an Artificial Horizon.

A flat dish, containing a small quantity of mercury, is generally used for this purpose. The surface of the mercury is horizontal, and is a good reflector of the sun's rays. Let the observer so stand that he may receive on his eye rays from the sun which have been reflected from the surface of the mercury. He will then, according to the principles of optics, see the reflected image of the sun as much below the surface of the mercury as the sun is above it. If, then, he looks at the image through the unsilvered part of the horizon-glass, instead of at the horizon, and brings the image of the sun reflected at the index-glass and horizon-glass into contact with this, it is evident that the angle observed will be double of the sun's altitude. The details of this process are the same as have been already explained. Having read off the angle when the contact has been made, it must be corrected for the index error; and the result, divided by 2, will be the apparent altitude of that limb of the sun which has been observed.

To Observe the Distance between the Moon and any Celestial Object with the Sextant.

1. *Between the Sun and Moon.*—Put the telescope in its place, and the wires parallel to the plane of the instrument; and if the sun is very bright, raise the plate before the silvered part of the speculum; direct the telescope to the transparent part of the horizon-glass, or to the line of separation of the silvered and transparent parts, according to the brightness of the sun; and turn down one of the coloured glasses. Then hold the sextant so that its plane produced may pass through the sun and moon, having its face upwards or downwards, according as the sun is to the right or left of the moon; direct the sight through the telescope to the moon, and move the index till the limb of the sun is nearly in contact with the illumined limb of the moon; now clamp the index, and, by a gentle motion of the instrument, make the image of the sun move alternately to one side and the other of the moon; and when in that position, where the limbs are nearest each other, make the contact of the limbs perfect by the tangent-screw; this being effected, read off the degrees and parts of a degree shown by the index on the limb, using the magnifying-glass; and thus the angular distance between the nearest limbs of the sun and moon is obtained.

2. *Distance between the Moon and a Planet or Star.*—Direct the middle of the field of the telescope to the line of separation of the silvered and transparent parts of the horizon-glass; if the moon is very bright, turn down the lightest-coloured glass, and hold the sextant so that its plane may be parallel to that passing through the eye of the observer and both objects; its face being upwards if the moon is to the right of the star, but downwards if it be to the left. Now direct the sight through the telescope to the star, and move the index till the moon appears by the reflection to be nearly in contact with the star; clamp the index, and turn the adjusting or tangent screw till the coincidence of the star and the enlightened limb of the moon is perfect; and the reading off of the limb at the index will be the observed distance between the moon's enlightened limb and the star.

The contact of the limbs must always be observed in the middle, between the parallel wires.

It is sometimes difficult for those not much accustomed to observations of this kind, to find the reflected image in the horizon-glass; it will perhaps, in this case, be found more convenient to look directly to the object, and, by moving the index, to make its image coincide with that seen directly.

SECT. II.—OF THE CORRECTIONS TO BE APPLIED TO OBSERVED ALTITUDES AND DISTANCES.

Observation Instruments.

1. *Parallax.*

In order that the place of a heavenly body may be fixed in space, it is necessary to suppose that all observations are taken from one point. This point is the centre of the earth. Consequently the places of the sun, moon, and planets, whose distances from the earth are measurable, as observed, must be reduced to what they would be if seen from the centre. The correction for this object is called parallax. The fixed stars are at so great a distance from the earth that they have no sensible parallax, and this correction is not to be applied to them.

Let C (fig. 47) be the centre of the earth, P the place of the observer on its surface, and Z his zenith; and let S be a heavenly body whose position is observed. Then ZPS is the observed zenith distance, or complement of the observed altitude, and ZCS the true zenith distance, —*i.e.*, the zenith distance as observed at the earth's centre.

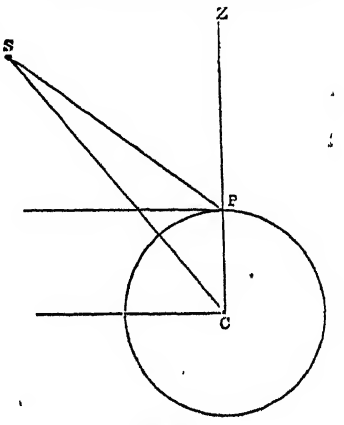

Fig. 47.

Then clearly the angle ZPS is greater than the angle ZCS by the angle PSC, which is also in the plane of the vertical circle through S. It is evident from the figure that a heavenly body is *depressed* by parallax; and the observed altitude is less than the true altitude by a certain amount depending on the altitude, which is called the correction of parallax. The correction of parallax, therefore, must always be applied with the positive sign. Its amount may be easily found; for, let $\angle ZPS = z'$, and $ZCS = z$, and PSC the parallax $= p$; then, in triangle PSC,

$$\text{Sin PSC} = \frac{PC}{SC} \sin SPC = \frac{PC}{SC} \sin SPZ.$$

Let $PC = r$, the radius of the earth, and $SC = R$, the distance of the heavenly body from C; also PSC is always very small, and $\sin PSC = PSC = p$ very nearly.

$$\text{Hence } p = \frac{r}{R} \sin z'.$$

r and R being invariable, p is greatest when $z' = 90°$, or when S is in the horizon. Let P be the value of p in this position; then

$$P = \frac{r}{R},$$

$$\text{and } p = P \sin z' = P \cos a',$$

if a' be the observed altitude.

This will illustrate the principle on which tables of correction for parallax for different heavenly bodies, as sun, moon, &c., for different angles of altitude, are calculated.

2. *Refraction.*

Refraction is a correction to be applied in consequence of the rays from every heavenly body being bent or refracted as they pass through the successive layers of the earth's atmosphere, in consequence of which they describe curvilinear paths, having their convexity turned towards the zenith of the observer. The tangent to this curve at the eye of the observer is the direction in which he sees the object, and is evidently, from what has been said, *bent towards* the zenith. Hence the effect of refraction is to *raise* the heavenly bodies in the heavens above their true

Observation Instruments.

places; and the correction must therefore be applied to the observed altitudes of all bodies with a negative sign.

The law which this correction follows is very complex; it is very great when the body is near the horizon, and vanishes when it is in the zenith. The best position of heavenly bodies for observation, so far as this correction is concerned, is near the zenith.

A table of this correction for every 5′ of altitude is calculated, and is to be found in all nautical tables.

3. *Correction for Semidiameter.*

When the sun or moon, or a planet, is observed, the altitude of one of the limbs is the observed altitude, the altitude of the centre must be obtained by adding or subtracting the semidiameter of the observed body according as the lower or upper limb is observed. The semidiameters of the sun and moon are continually changing; and tables are given in the *Nautical Almanac* of their values at noon of every day at Greenwich, and in the case of the moon at midnight also. Their values at any intermediate hour may be calculated from these, as will be more fully shown hereafter.

This correction is not to be applied when a fixed s ar is the object observed.

4. *Correction for Dip.*

The altitude is supposed to be observed from the true horizon—*i.e.*, from a horizontal plane through the place of the observer. This, however, is never the case, for the observer's eye must then be on the earth's surface. It is, in fact, always elevated above it, and the apparent horizon is depressed in consequence below the true horizon.

The nature of this correction will be easily seen from fig. 48. B the place of observation at a distance AB = d feet above the surface, BH′ touching the surface at H′; then BH′ is the plane of the sensible horizon; S a heavenly body to be observed. Draw Bh parallel to AH, the true horizon of A, and let BH′ and AH intersect in J. Then, since AB is very small compared with BS and AS, the $\angle$ hBS may be considered as equal to HAS. Also let R = earth's radius, CA or CH′. Hence observed altitude of S

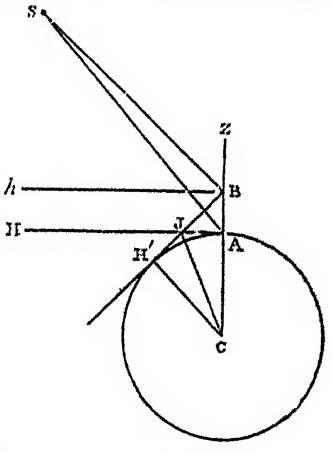

Fig. 48.

$$= \text{H}'\text{BS} = h\text{BS} + h\text{BH}'$$
$$= h\text{BS} + \text{AJB} = h\text{BS} + \text{ACH}'.$$

Or true altitude = observed altitude − ACH′.

$$\text{Now tan ACH}' = \frac{\text{BH}'}{\text{CH}'} = \frac{\sqrt{(2\text{R}+d)\,d}}{\text{R}}$$

$$= \sqrt{\frac{2d}{\text{R}}} \text{ nearly, because } \frac{d^2}{\text{R}^2} \text{ may be neglected in comparison of } \frac{d}{\text{R}}.$$

Also ACH′ = tan ACH′ nearly;

$$\therefore \text{ ACH}' = \sqrt{\frac{2d}{\text{R}}}$$

Now R in feet = 6120 × 3958.

Hence ACH′ in seconds

$$= 57{\cdot}29577 \times 60 \times 60 \times \sqrt{\frac{2d}{6120 \times 3958}}$$

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Hence, putting d = 1, 2, 3, &c., feet respectively, we can find the dip when the eye is 1, 2, 3, &c., feet respectively above the surface.

Whence tables for the dip at different elevations may be calculated.

5. *Index Error.*

This error has already been explained.

It will be observed that all observed altitudes are affected with *refraction* and *dip*, of which the first is always subtractive, and the second is subtractive in all observations, except when the back horizon-glass of the quadrant is made use of, when it is additive.

Parallax and semidiameter affect only those bodies whose distance from the earth is not very great, and which have a sensible diameter, as the sun and moon; but no fixed stars. Parallax is always additive; and the semidiameter is to be added or subtracted according as the lower or upper limb of the heavenly body is observed.

Chap. II.—PRELIMINARY PROBLEMS IN NAUTICAL ASTRONOMY, AND USE OF NAUTICAL ALMANAC AND TABLES.

Sect. I.—OF TIME.

A day is the interval between two successive transits of a heavenly body over the meridian, and derives its name from the body whose motion is observed; and of whatever denomination it be, it is divided into 24 hours, each hour into 60 minutes, and each minute into 60 seconds. The interval between two successive transits of the sun is a solar day; of the moon, a lunar day; of a fixed star, a sidereal day. The earth's revolution about her axis is performed always in the same time; hence if all the heavenly bodies retained the same position with regard to one another, all days of whatever name would be of the same length. The sun (or, more strictly speaking, the earth), the moon, and planets are always varying their position with respect to one another and the fixed stars; and they move with velocities not only different from each other, but variable in different parts of their own orbits. The length of the day, therefore, determined by these bodies is variable. In order to obtain a definite and uniform measure of time, the *mean solar day*, which is the average of all the apparent solar days in the year, is employed. An imaginary body, called the *mean sun*, is supposed to describe the equator uniformly with the true sun's average or mean daily motion, and the interval between two successive transits of this imaginary sun is a *mean solar day*.

Clocks and chronometers are adapted to mean solar time; so that a complete revolution through twenty-four hours of the hour-hand of one of these instruments would exactly correspond with the revolution of the earth about her axis with regard to the mean sun. Time reckoned in mean solar days and parts of mean solar days is called *mean solar time*.

The true sun sometimes passes the meridian before and sometimes after the mean sun; the difference in time of the transits of the true and mean suns is called the *equation of time*, and is sometimes to be added and sometimes to be subtracted from the one of these times to obtain the other, as is pointed out in the *Nautical Almanac*.

As the earth revolves about her axis from E. to W., different meridians successively come under the mean sun; and since, after the lapse of twenty-four mean solar hours,

Nautical Astronomy

the same meridian again comes under the sun; it follows that for every 15° of longitude between the places, there is a difference of 1h of mean time; and that mean noon is 1h earlier for every 15° of E. longitude, and 1h later for every 15° of W. longitude.

A sidereal day is the interval between two successive transits over the same meridian of the vernal equinox, or the first point of Aries. This is not strictly a uniform measure because of the change of the position of this point of Aries in consequence of precession and nutation. Time, therefore, so reckoned, ought strictly to be called apparent sidereal time; and *mean sidereal time* to be reckoned from the transit not of the true but of the mean equinoctial point. The smallness of the fluctuations to which a clock regulated to *apparent* sidereal time, compared with one regulated to *mean* sidereal time, is subject, amounting at the utmost to 2s·3 in 19 years, has prevented the practical inconvenience of this being felt; no clock being sufficiently perfect to go for so long a period without requiring frequently to be re-adjusted.

The sun's apparent revolution in his orbit round the earth takes place in 365·242218 mean solar days; the mean sun, therefore, describes an angle of 59′ 8″·33 in a mean solar day; hence, in the interval between two successive transits of the mean sun over the same meridian, the earth revolves through 360° 59′ 8″·33; but in a sidereal day the earth revolves through 360°. Whence we obtain the proportion—

A sidereal day: a mean solar day:: 360° : 360° 59′ 8″·33.

Whence also it is evident that, if the same interval of absolute time be expressed in *mean solar* and also in *sidereal time*, it will be greater in the latter denomination than in the former.

Tables are calculated for the *acceleration* of sidereal on *mean solar* time, and, conversely, for the *retardation* of mean solar on *sidereal* time, which are useful for converting intervals of sidereal into mean solar time, and conversely. These are to be found at page 516 of the *Nautical Almanac*.

Astronomical mean time always begins at noon, and goes on to the succeeding noon through 24 hours; so that a clock which shows astronomical mean time, set for any place (as Greenwich), shows 0h 0m 0s when the mean sun is on the meridian, and shows 24 hours, or 0h 0m 0s, when the mean sun is again on the meridian.

A clock set to show sidereal time shows 0h 0m 0s when the mean equinoctial point is on the meridian, and shows 24 hours, or 0h 0m 0s, again when this point is next on the meridian.

Sidereal Time, in the *Nautical Almanac*, is the sidereal time at mean noon for the meridian of Greenwich; or, in other words, the hour angle of the equinoctial point when the mean sun is on this meridian; and is very useful in all cases where mean time is to be deduced from observations of heavenly bodies.

The civil day is reckoned from midnight to midnight, and is divided into 12 hours, from midnight to noon, called A.M.; and into 12 hours, from noon to midnight, called P.M. Evidently time P.M., and astronomical mean time up to midnight, are the same. But for time A.M., add 12 hours, and date the day one back.

Thus, June 3, 7h 5m 27s P.M. is, June 3, 7h 5m 27s astronomical time; but, June 3, 5h 12m 37s A.M. is, June 2, 17h 12m 37s A.M.

Conversely, if the astronomical time is given, and the corresponding civil time is required, if under 12 hours, the given time is the same time P.M. for the same date; if above 12 hours, subtract 12 hours from it, and date the day one forward, and the result is civil time A.M.

Thus, September 18, 7h 10m 15s is, September 18, 7h 10m 15s P.M.; but September 18, 22h 13m 45s astronomical is, September 19, 10h 13m 45s A.M.

Nautical Astronomy

PROB. 1.—To convert degrees, or parts of the equator, into time.

Rule.—Divide the degrees by 15; the result gives hours. Multiply the remaining degrees, if any, by 4; the result is minutes. Divide the number of minutes by 15 for minutes, and then multiply the remaining minutes by 4 for seconds. Divide the seconds by 15 for seconds, and decimals of seconds, if necessary.

Ex. 1.—Reduce 26° 45′ to time.

Divide 26 by 15, the quotient is 1, with remainder 11. Hence, by the rule—

26°	=	1h	44m
45′	=	0	3
or 26° 45′	=	1	47.

Ex. 2.—Reduce 139° 48′ 18″ to time.

139°	=	9h	16m	0s
48′	=	0	3	12
18″	=	0	0	1·2
or 139° 48′ 18″	=	9	19	13·2.

PROB. 2.—To convert time into degrees, minutes, and seconds.

Rule.—Multiply the given time by 10, and add to the result half of the product. The result will be the corresponding degrees, minutes, and seconds.

Ex.—Convert 3h 4m 28s into degrees, &c.

	3h	4m	28s
			10
	30	44	40
One half =	15	22	20
	46	7	0

Answer..... 46° 7′.

PROB. 3.—Given the time under any known meridian, to find the corresponding time at Greenwich.

Rule.—Let the given time be reckoned from the preceding noon to turn it into astronomical time; convert the longitude of the known meridian into time, which add to the given time if the place be W. of Greenwich, and subtract from the given time if it be E.; and, if necessary, increase the time by 24 hours, reckoning the day one back. If the resulting time exceed 24 hours, put the date one day forward, and subtract 24 hours.

Ex. 1.—It is 6h 15m P.M., June 23, in a ship whose longitude is 76° 45′ W.

76° 45′ = 5h 7m.

Given time, June 23.....	6h	15m	
Longitude.....	5	7	W.
Time at Greenwich.....	11	22	June 23.

Ex. 2.—The time at a ship in longitude 139° 48′ 15″ E. is, July 24, 5h 25m 20s P.M.; required the Greenwich time.

139°	=	9h	16m 0s
48′	=	0	3 12
15″	=	0	0 1
		9	19 13

This being greater than the given time, we next add 24h to the latter, and we have—

	29h	25m	20s	
	9	19	13	
Time at Greenwich.....	20	6	7	July 23.
Or civil time.....	8	6	7	A.M. July 24.

Ex. 3.—The time at a ship in longitude 175° 45′ W. is, June 28, 4h 18m 12s A.M.; what is the Greenwich time?

175°	=	11h	40m
45′	=	0	3
Longitude	=	11	43 W.

Time at ship is, June 27.....	16h	18m	12s	
Longitude.....	11	43	0	W.
Time.....	28	1	12	June 27.
Or.....	4	1	12	June 28.

Nautical Astronomy

Ex. 4.—The time at a ship in longitude 178° E. is, October 14, $3^h\ 15^m$ A.M.; what is the time at Greenwich?

$3^h\ 15^m$ A.M. on Oct. 14... =	Oct. 13,	$15^h\ 15^m\ 0^s$
Longitude 178° ..... =		11 52 0 E.
Time at Greenwich. =	Oct. 13,	3 23 0

PROB. 4.—To find the Greenwich time by a chronometer whose error on Greenwich mean time is known.

Rule.—Add or subtract the error of the chronometer to the time shown by it, according as it is slow or fast; the result is Greenwich time. Sometimes 12 hours must be added to this result, and the day reckoned one back. The best way to obviate this error, is to obtain Greenwich time approximately, by Problem 3, by help of the ship's mean time and longitude by account; if the difference between the two (Greenwich) dates, so found in these two ways, is nearly 12 hours, then the date by chronometer must be increased by 12 hours, and the day reckoned one back if necessary, so as to make the two dates agree in the day and hour nearly.

Ex. 1.—June 15, 1857, at $7^h\ 45^m$ P.M. mean time nearly, in longitude 45° W., a chronometer showed $10^h\ 53^m\ 12^s$, being $3^m\ 15^s$ fast; required the Greenwich time.

By Chronometer.		By Rule 3.	
June 15, Chronometer	$10^h\ 53^m\ 12^s$	Ship, June 15....	$7^h\ 45^m$
Error on Greenwich mean time (fast)	0 3 15	Longitude.....	3 0 W.
Greenwich time	10 49 57	Greenwich time,	10 45

Ex. 2.—October 12, 1857, at $11^h\ 45^m$ P.M., in longitude 110° 35′ W., a chronometer showed $7^h\ 0^m\ 40^s$, being $9^m\ 5^s$ slow; required the Greenwich date.

By Chronometer.		By Rule 3.	
Oct. 12.....	$7^h\ 0^m\ 40^s$	Ship, Oct. 12.....	$11^h\ 45^m\ 0^s$
Error (slow).....	0 9 5	Longitude	7 22 20
	7 9 45	Greenw., Oct. 12...	19 7 20
	12 0 0		
Greenwich, Oct. 12,	19 9 45		

PROB. 5.—Given the Greenwich date, to find the date under a given meridian.

Rule.—The Greenwich date being reduced to the preceding noon, reduce the longitude to time, and subtract it from Greenwich date, increased by 24 hours, and put one day back if necessary, if the longitude be W.; and add if the longitude be E.

Ex. 1.—An eclipse of the moon commenced at Greenwich, December 25, 1852, at $22^h\ 14^m\ 36^s$; at what time did it begin at a place in longitude 175° E.?

Greenwich time, Dec. 25.....	$22^h\ 14^m\ 36^s$
Longitude.....	11 40 E.
	33 54
(*i.e.*) December 26.....	9 54

Ex. 2.—On the 6th of December 1857, at 9^h at Greenwich, the distance of the moon from the sun was 106° 44′ 34″; at what time will the distance be the same in longitude 168° 15′ 43″ W.?

Long. = $11^h\ 13^m\ 2{\cdot}86$ W. Greenwich, Dec. 5..... $33^h\ 0^m\ 0^s$
Add 24 to Greenwich time. Longitude..... 11 13 2·86 W.
Date required, Dec. 5..... 21 46 57·14.

SECT. II.—OF THE SUN'S DECLINATION, RIGHT ASCENSION, EQUATION OF TIME, AND SEMIDIAMETER AND SIDEREAL TIME.

All of these quantities are given in the *Nautical Almanac* for the noon of every day. They all vary, and consequently their value at any time intermediate between two successive noons is different from that at either noon. For ordinary purposes, it is sufficient to suppose that the change of these quantities is proportional to the time from the preceding noon. Hence, if the difference of the value between the preceding and succeeding noon is taken from the *Nautical Almanac*, a simple proportion will give the quantity to be applied to the value at the preceding noon, which must be added if the quantity is increasing, and subtracted if it be decreasing. As the values of the quantities are given for Greenwich noon, it is necessary to reduce the ship's time to Greenwich time, in order to obtain their proper value.

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This process may be materially shortened by the use of proportional logarithms, which are given in nautical tables, and to which the reader is referred for an explanation. For example, to take out the sun's declination at a given time in a given place, get a Greenwich date, as already explained; take out from the *Nautical Almanac* the declination at two successive noons between which the date lies; take their difference; take out from the tables the logarithm of the Greenwich date of the sun; add to it the proportional logarithm for the change in 24 hours;—the result is the proportional logarithm of the change of declination for the given time. This will be found from the table, and added or subtracted, according as the declination is increasing or decreasing. Sometimes the declination at two successive noons will be of different names; the difference must then be found by adding them.

The very same mode applies to finding the equation of time, and also the sun's apparent right ascension.

The sun's semidiameter may always be taken to be that corresponding to the nearest noon.

The right ascension of the mean sun, called in the *Nautical Almanac* the *sidereal time*, may be found for any other meridian than Greenwich in the same way. Since, however, the motion of the mean sun is uniform throughout the year, the change in any given number of hours, minutes, and seconds is the same for all days, and can be found at once from the "Table of Time Equivalents" given in the *Nautical Almanac*.

Opposite to each of these quantities in the *Nautical Almanac* is given the difference for one hour, which enables us to find the quantity for any other hour than noon, by multiplying this hourly difference by the number of hours in the date from noon, and adding to it the proportional parts for the additional minutes and seconds, and applying this difference to the value for the preceding noon, with a positive or negative sign, according as the quantity is increasing or decreasing.

The following examples will illustrate these directions:—

Ex. 1.—October 11, 1857, in Long. 36° 45′ E., at $7^h\ 45^m$ A.M.; required the sun's declination, right ascension, equation of time, and sidereal time, *i.e.*, the right ascension of the mean sun when crossing the meridian of observer.

October 11, $7^h\ 45^m$ A.M. civil is, October 10...	$19^h\ 45^m$
Longitude	2 27 E.
Greenwich date, Oct. 10.....	17 18

To find Declination.—(1.) By proportional logarithms, from *Nautical Almanac*.

Declination, Oct. 10.....	6° 44′ 0″·9	S.
„ „ 11.....	7 6 43·5	S.
Diff. for 24^h	0 22 42·6	

Greenwich date, logarithm of ⊙.....	=	·14217
Proportional logarithm for 22′ 42″·6	=	·89925
Prop. log. for 16′ 22″.....		1·04142

Declination at noon, October 10..	6° 44′ 0″·9	S.
Increase in $17^h\ 18^m$	0 16 22	
Declination required	7 0 22·9	S.

(2.) By hourly differences.

Difference for 1^h, October 10, 56″·77 from *Nautical Almanac*.

17^h
39739
5677
965·09

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965·09 .... =16′ 5″·09 difference for 17h.
15m is ¼ ..... 14·19
3m is 1/20 ..... 2·83
16 22·11
Declination, October 10.. 6° 44 0·9
Declination required... 7 0 23·01

To find right ascension.

Right ascension, Greenwich, October 10	... 13h	3m 8s·80
„ „ „ 11	... 13	6 50·02
	0	3 41·22
Greenwich date logarithm of ⊙	=	·14217
Prop. log. for 3m 41s	=	1·68903
Prop. log. for 2m 39s		1·83120
Sun's right ascension at noon, October 10	... 13h	3m 8s·80
Increase in 17h 18m	0	2 39
Sun's right ascension required	... 13	5 47·80

Or, from *Nautical Almanac*—

Difference for 1h ..... 9·216
17
64512
9216
156·672
15m is ¼ ..... 2·304
3 is 1/20 ..... ·461
159·437 or 2m 39s nearly.

Sun's right ascension, October 10, noon	.... 13h	3m 8s·80
Increase for 17h 18m	0	2 39
Right ascension required	... 13	5 47

To find equation of time.

Equation of time, October 10	... 12m	59s·81
„ „ 11	... 13	15·15
	0	15·34
Greenwich date log. of ⊙	=	·14217
Prop. log. for 15s·3	=	2·84873
Prop. log. for 11s		2·99090
Equation of time, October 10	... 12m	59s·81
Increase in 17h 18m	... 0	11
	13	10·91

Or, from *Nautical Almanac*—
Increase for 1h ..... 0″·639
17
4473
639
10·863
15m is ¼ 129
3 is 1/20 25
11·017 or 11s nearly,

which, added to the equation of time at mean noon of October 10, gives 13m 10s·81 for equation of time required.

Right ascension mean sun, October 10	... 13h	16m 8s·61
„ „ „ 11	... 13	20 5·17
Difference	... 0	3 56·56
Greenwich date of ⊙	=	·14217
Prop. log. for 3m 56s	=	1·66051
Prop. log. for 2m 50s		1·80268
October 10	... 13h	16m 8s·61
Increase	... 0	2 50
Mean sun's r. ascen. or sidereal time,	13	18 58·61

Or, by table of time equivalents,

Mean sun's right ascension, October 10	... 13h	16m 8s·61
Correction for 17h	... 0	2 47
Correction for 18m	... 0	0 3
Mean sun's right ascension required..	13	18 58·61

Ex. 2.—To find the sun's declination at a place in Long. 97° 45′ W., at 3h 46m P.M., on 20th March 1857,—Greenwich date, March 20, 10h 17m.

Sun's declination, March 20	... 0°	3′ 35″·5 S.
„ „ 21	... 0	20 6·1 N.
Difference	... 0	23 41·6

Greenwich date logarithm ⊙	=	·36808
Prop. log. for 23′ 41″	=	·88083
Prop. log. for 10m 9s		1·24891

Declination ..... 6′ 33″·5 N.

Or, by hourly difference,

Difference for 1h, March 20	59″·23
	10
Difference for 10h	592·30
15m is ¼	14·80
2m is 3/20	1·97
	609·07
Correction	10m 9s
And the declination, subtracting from this	3 35·5
Gives, as before	6′ 33″·5 N.

SECT. III.—OF TAKING OUT MOON'S DECLINATION, RIGHT ASCENSION, SEMIDIAMETER, AND HORIZONTAL PARALLAX.

The moon's declination and right ascension are given for every hour in the *Nautical Almanac;* and the difference for 10m at the beginning of every hour is recorded. From these data, the moon's declination and right ascension at any hour can be readily obtained; for by multiplying the difference for 10m by the number of intervals of 10m in the given time since the last hour, and taking parts for the additional minutes and seconds, and adding the result if the declination be increasing, and subtracting if decreasing, to the declination at the last preceding hour, we shall find the declination. The difference must always be added to the right ascension. Or they may be found by a table of logistic logarithms: thus, add together the logistic logarithms of the minutes and seconds in the Greenwich date, and the proportional logarithms of the difference; the result will be the proportional logarithm of the correction to be applied.

The moon's semidiameter and horizontal parallax are given in the *Nautical Almanac* for every 12h,—viz., from mean noon to mean midnight, and mean midnight to mean noon, of every day at Greenwich. Hence we may proceed as for the sun's right ascension and declination, except that we must always take out of the table the declination or right ascension for the mean noon or mean midnight, according as the time lies between noon and midnight or midnight and noon; and if the Greenwich date exceed 12h, we must subtract 12h from it, and reckon the difference from the preceding midnight.

Ex. 1.—August 10, 1857, in Long. 84° 30′ E., at 7h 44m 15s P.M.; required the moon's right ascension and declination.

Ship, August 10	... 7h	44m 15s
Longitude	... 5	38 0 E.
Greenwich date, August 10,	2	6 15

Moon's r. ascen., Aug. 10, 2h,	1h 8m	43s·49
„ „ 3	1 10	50·91
Difference	0	2 7·42
Log. log.... 6m 15s =		·98227
P. log. for.. 2 7 =	1	92962
P. log. for.. 0 13		2·91189
Moon's r. ascen., Aug. 10, 2h,	1h 8m	43s·49
Correction	0 0	13
Moon's right ascen. required,	1 8	56·49

Or for right ascension—
Difference for 1h ... 2m 7s·42
6m is 1/10 ..... 12·742
15s is 9/25 530
13·272
Or correction is 13s, as before.

Decl., 9° 22′	48″·7	N
„ 9	38 55·1	N.
Difference	0	15 6·4
Log. log.... 6m 15s =		·78227
P. log. for.. 16 6 =		1·04845
P. log. for.. 1 41		2·03072
Decl., 12h,	9° 22′	48″·7
Cor.....	0	1 41
Decl. req.,	9 24	29·7

Or for declination—
Difference for 10m ... = 161·05
5m is ¼ ..... 80·52
1 is 1/10 ..... 16·10
15s is ¼ 4 02
100·62
Or correction is 1m 41s, as before.

Ex. 2.—September 12, 1857, in Long. 149° 18′ W., at 5h 36m P.M.; required the moon's semidiameter and horizontal parallax.

Ship, September 12	... 5h	36m 0s
Longitude	... 9	57 12 W.
Greenwich, September 12...	15	33 12

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Moon's Semidiameter.		Moon's Horizontal Parallax.	
Sept. 12, midnight	15′ 53″·2	Sept. 12, midnight	55′ 10″
Sept. 13, noon	15 49·3	Sept. 13, noon	57 55·9
Difference	0 3·7	Difference	0 14·1

And both are decreasing.

Greenwich date log ☽ 3h 35m	= ·52895	Greenwich date log ☽	= ·52895
Prop. log. for 3″·7	= 3·46522	Prop. log. for 14″·1	= 2·88420
Prop. log. for 1″·1 ..	3·99417	Prop. log. for 4″·2	3·41315

Moon's semidiameter at 15h 33m 12s, ...	= 15′ 52″·1	Horiz. parallax at 15h 33m 12s	= 58′ 5″·8

These problems may also be solved by simply taking the proportional parts. Thus, for the horizontal parallax—

Difference for 12h	14″·1
3h is ¼	3·5
30m is ⅛	·58
	4·08

Or the correction is 4″.

And for semidiameter—

Difference for 12h	3″·7
3h is ¼	·92
30m is ⅛	·15
	1·07

Or the correction is 1″·07.

SECT. IV.—OF LUNAR DISTANCES.

PROB.—Having given a lunar distance, to find its Greenwich date.

Rule.—Lunar distances are found for every third hour of Greenwich mean time, and are recorded in the *Nautical Almanac*, as also the proportional logarithms of the differences of the distances at intervals of every three hours. To find, then, the Greenwich date corresponding to a given distance, find in the table the *nearest* distance preceding in order of time the given distance, and take the difference between it and the given distance; from the proportional logarithm of this difference subtract the proportional logarithm of the said nearest distance; the remainder will be the proportional logarithm of the correction to be applied to the Greenwich date answering to the nearest distance in order to obtain the approximate Greenwich time.

The distances are here supposed to increase uniformly, which is not the case. It is therefore necessary to apply a correction to the time above obtained, if great accuracy is required. This may be found by help of a "Table showing the Corrections required on account of Second Differences," in the *Nautical Almanac*, as follows:—(1.) Find the approximate interval by the preceding rule. (2.) Take the difference between the proportional logarithms which stand opposite to the distances which include the given distance. (3.) Look down the column in the table at the head of which is this difference of proportional logarithms, and along the column at the left hand side of which stands the approximate interval; the number so found is the correction, which is to be added to the approximate time if the proportional logarithms are decreasing, and subtracted if they are increasing.

Ex.—Required the time at Greenwich at which the *reduced* distance of the moon from Jupiter will be 42° 55′ 18″ on the 23d December 1857.

From the table, it appears this will be between noon and 3h. The *nearest* distance preceding therefore is,—

Distance at noon.....	43° 58′ 19″	Propor. log.....	·2590
Reduced distance.....	42 55 18		
Difference.....	1 3 1	Propor. log.....	·4558
Approximate interval	1h 54m 24s	,, ...	·1968

The difference of proportional logarithms at noon and 3h is 12; and on looking in the table for second differences down the column headed (″), and along the column on the left of which is 2h, the nearest to the approximate interval, we find 3s the correction, which is to be added, as the proportional logarithms are decreasing. Hence the Greenwich time is 1h 54m 27s.

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SECT. V.—OF MEAN AND APPARENT SOLAR TIME, AND SIDEREAL TIME.

PROB. 1.—Given mean solar time at any given place, to find apparent solar time; and, conversely, given apparent, to find mean solar time.

Find the time at Greenwich, and correct the equation of time for this date. The equation of time so corrected applied to the given time, with the proper sign (as shown in the *Nautical Almanac*), will give the time required.

Ex. 1.—June 16, 1857, mean solar time 8h 15m P.M., in longitude 25° W.; to find the apparent time.

Ship, June 16.....		8h	15m
Longitude		1	40 W.
Greenwich, June 16		9	55
Equation of time (p. 11, *Nautical Almanac*) *subtractive*			
June 16.....	19s·43		
,, 17.....	32s·34		
Difference.....	12s·91		
Greenwich date, log. ☉	= ·38385		
Propor. log. for 12s·9	= 2·92283		
Propor. log. for 5s·3.....	3·30668		
Equation of time.....	−0h 0m 24s·73		
Ship, June 16	8 15 0		
Apparent time, ship	8 14 35·27		

Ex. 2.—Oct. 15, 1857, at 6h 51m P.M., apparent time, in Long. 113° 45′ E.; find mean time.

Ship, Oct. 15.....		6h	51m
Longitude		7	35 E.
Greenwich, Oct. 14.....		23	16
Equation of time (p. 1, *Nautical Almanac*)—			
Oct. 14	−13m 57s·92		
,, 15	14 11 ·12		
Difference	0 13 ·20		
Difference for 1h.....	·550		
	23		
	1650		
	1100		
Difference for 23h.....	12·650		
15m is ¼.....	·137		
1m is 1/15	·009		
	12·796		

Or 12s·8 nearly.

Hence mean time at ship, 6h 50m 47s·2 P.M., Oct. 15.

PROB. 2.—Given solar time, to find sidereal time.

Rule.—If the given time be *mean solar*, find the Greenwich date; correct the right ascension of mean sun for this date, and add to the mean time at ship; the result is sidereal time.

If the given time is *apparent solar*, convert it into mean solar time, as in Problem 1, and proceed as before.

Ex.—Nov. 18, 1857, at 9h 35m 30s A.M., mean time, in Long. 18° 7′ W.; required the sidereal time.

Ship, Nov. 17	21h	35m	30s
Longitude	1	12	28 W.
Greenwich, Nov. 17th	20	47	58
Right ascension of mean sun, Nov. 17.....	15	45	57·72
Correction for 22h	0	3	36·84
,, 47m.....	0	0	7·72
,, 58s.....	0	0	0·16
Right ascension of mean sun.....	15	49	42·44
Ship mean time.....	21	35	30
Sidereal time	13	25	12·44

Rejecting 24h in the result.

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By help of the last problem, we may find what bright stars in the catalogue of the *Nautical Almanac* will be on the meridian of a given place next after any time, mean or apparent.

For, having found the sidereal time at a ship, it is evident that the star whose right ascension is next greater, is the first that will pass the meridian in question.

It is sometimes required to find all the bright stars that will pass a given meridian between two specified hours. We must in that case find the sidereal time for both hours, and all the bright stars in the catalogue whose right ascensions lie between these limits will pass the given meridian between the specified hours.

Ex. 1.—To find what bright star will pass the meridian in Long. 18° 7′ W., on November 18, 1857; next after $9^h\ 35^m\ 30^s$ A.M. (See Example to Problem 2.)

Looking in the catalogue of bright stars in the *Nautical Almanac*, we find that the bright star whose right ascension is the next greater than $13^h\ 25^m\ 12^s{\cdot}44$, is β Corvi, which is the star required.

Ex. 2.—What bright stars in the *Nautical Almanac* passed the meridian of a place in Long. 64° E., between the hours of 6 and 9, on March 10, 1857?

Ship, March 10	6^h	0^m	0^s	9^h	0^m	0^s
Longitude	4 16	0 E.		4 16	0 E.	
Greenwich, March 10	1 44	0		4 44	0	
(1.) Right ascension of mean sun—						
Greenwich, March 10	23^h	12^m	$25^s{\cdot}64$			
Correction for $1^h\ 0^m$	0	0	9·8565			
„ 0 44	0	0	7·2281			
	23	12	42·726			
Ship, March 10	6	0	0			
Sidereal time	5	12	42·7246 (I.)			
(2.) Right ascension of mean sun—						
Greenwich, March 10	23^h	12^m	$25^s{\cdot}64$			
Correction for $4^h\ 0^m$	0	0	39·4259			
„ 0 44	0	0	7·2281			
	23	13	12·2940			
Ship	9					
Sidereal time	8	13	12·2940 (II.)			

On looking at the catalogue, we find that the stars whose right ascensions lie between these limits are from β Tauri to 15 Argus, which are the stars required.

Prob. 3.—Given sidereal, to find mean solar time.

Rule.—Take out of the *Nautical Almanac* the right ascension of the mean sun for noon of the given day. Subtract this from the sidereal time, increased, if necessary, by 24 hours; the remainder is mean time nearly. By help of the table which gives the relation of mean solar and sidereal time already referred to, correct this approximate time, and the result will be the mean time required.

Ex.—July 21, 1857, when a sidereal clock showed $6^h\ 45^m\ 35^s$ find the mean time.

Sidereal time				6^h	45^m	35^s
Right ascension mean sun at mean noon.				7	56	47·66
Mean time nearly				22	48	47·34
Correction for 22^h	3^m	$46^s{\cdot}69$				
„ 48^m	0	7·88				
„ 47^s	0	0·13		0	3	54·60
Mean time				22	44	52·74

By means of the above we can find the error of a clock or chronometer by comparing the time shown by it with that of a sidereal clock in an observatory. Thus, Greenwich, November 4, 1857, a sidereal clock showed $18^h\ 15^m\ 30^s$, and a chronometer showed $3^h\ 28^m\ 15^s$, the sidereal clock being $3^m\ 13^s{\cdot}5$ slow; required the error of the chronometer.

Sidereal clock				18^h	15^m	30^s
Error (slow)				0	3	13·5
Sidereal time				18	18	43·5
R. ascen. of mean sun at mean noon				14	54	42·49
Mean time nearly				3	24	1·01
Correction for 3^h			$29^s{\cdot}57$			
„ 24^m			3·94			
„ 1^s			0	0	0	33·51
Mean time				3	23	27·50
Chronometer				3	28	15·0
Error (fast)				0	4	48·5

Prob. 4.—To find at what time any heavenly body will pass the meridian of a given place on a given day.

Nautical Astronomy

Rule.—From the right ascension of the given star taken out of the *Nautical Almanac*, increased, if necessary, by 24 hours, subtract the right ascension of the mean sun at mean noon (or *sidereal time*, as it is called in the *Nautical Almanac*). This gives the mean time at the ship approximately. Apply the longitude to this, and thus get a Greenwich date, and by this date correct the right ascension of the mean sun, and subtract the quantity so found from the star's right ascension; this will be the time required.

Ex.—At what time will β Corvi pass the meridian of a place in Long. 62° 20′ E., on July 24, 1857?

Right ascension β Corvi, July 24	12^h	26^m	$53^s{\cdot}88$
Right ascension of mean sun at mean noon (sidereal time, *Naut. Almanac*)	8	8	37·33
Sidereal time ship, approximate	4	18	16·55
Longitude	4	9	20·0 E.
Greenwich date, July 24	0^h	8^m	$56^s{\cdot}55$
Right ascension of mean sun at mean noon	8	8	37·33
Correction for 8^m	0	0	1·31
„ 56^s	0	0	0·15
Right ascension of mean sun	8	8	38·79
„ β Corvi	12	26	53·88
Time of star's passing the meridian.	4	18	15·09

SECT. VI.—OF THE MOON'S AUGMENTATION—CORRECTION OF SEMIDIAMETER ON ACCOUNT OF REFRACTION—THE MOON'S MERIDIAN PASSAGE, &c., &c.

1. *Of the Moon's Augmentation.*—The moon's semidiameter given in the *Nautical Almanac* is calculated as if seen from the earth's centre. Moreover, on account of the comparatively moderate distance of the moon from the earth, the moon's semidiameter subtends an angle at the earth's surface which sensibly varies with the altitude, being greatest when the moon is in the zenith, and least when in the horizon of the observer. The correction to be applied to the semidiameter from this cause is called the augmentation. It is computed for every degree of altitude, and is to be found in all nautical tables.

2. *Contraction of Moon's Semidiameter on account of Refraction.*—The correction for refraction varies very rapidly near the horizon, and consequently the moon's lower limb is sensibly more raised than the upper; and the moon's apparent form is that of an ellipse instead of a circle. Hence, in taking a lunar distance when the moon is near the horizon, the moon's semidiameter to be added to the observed distance, as taken from the tables, is greater than it ought to be; and a correction must be applied in consequence of the moon's diameter being an oblique diameter of the elliptic face, and not the horizontal or greatest diameter. This correction is always subtractive, and is given in nautical tables.

3. *Of the Moon's Meridian Passage.*—In west longitude the moon crosses the meridian later with regard to the sun than at Greenwich, and in east longitude earlier; because the moon's distance from the sun in right ascension is constantly changing. Hence to the Greenwich meridian passage of the moon must be applied a correction for every other place, depending on the longitude. All nautical tables contain this correction.

The corrections to be applied to the observed altitudes and distances of the heavenly bodies have been now sufficiently explained, and the reader will, with a little experience, easily understand how the several corrections are to be taken out of the tables. Index error, dip, and refraction are common to all observed altitudes, and must be applied in the order in which they are here set down. If the body observed be a star, this is all that is required.

Finding the Latitude.

If a planet, the parallax for the given altitude, taken from the proper table, must be added. If the observed body be the sun, after the dip apply the sun's semidiameter, and then correct for refraction and parallax. These two corrections are frequently given together, under the name of *correction in altitude*, which is always subtractive, because the refraction is always greater than the parallax. If the observed body be the moon, the semidiameter and horizontal parallax cannot be considered as invariable for 24 hours; they must therefore be corrected for the proper Greenwich date, as already pointed out. To the semidiameter thus corrected must be added the augmentation, from the proper table: The rest of the process is exactly the same as for the sun.

Ex. 1.—Feb. 1, 1857, at $2^h\ 40^m$ P.M., in Lat. 53° 20′ N., and Long. 13° 20′ E., the observed altitude of the sun's lower limb was 13° 35′, the index error was + 1′ 20″, and the height of the eye above the sea 18 feet; to find the sun's true altitude.

Observed altitude		13°	35′ 0″
Index correction	+	0	1 20
		13	36 20
Dip	−	0	3 33
		13	32 47
Sun's apparent diameter	+	0	16 15
Apparent altitude		13	49 12
Correction in altitude		0	3 45
Sun's true altitude		13	45 17

Ex. 2.—August 24, 1857, in Long. 18° 20′ W., the observed meridian altitude of the moon's lower limb was 54° 30′ 20″, the index correction was + 2′ 20″, and height of the eye above the sea 20 feet; required the moon's true altitude.

August 24. Time at ship ..... $0^h\ 0^m\ 0^s$
Longitude ..... 1 13 20 W.

Greenwich date, August 24 ..... 1 13 20

Moon's semidiameter,		Moon's horizontal parallax,	
24th, Noon	14′ 54″·4	24th, Noon	54′ 34″·7
Midnight	14 52·0	Midnight	54 25·9
	0 2·4		0 8·8
Greenwich date, log. moon	·99101	Log. moon	·99101
Prop. log. for 2″·4	3·65321	Prop. log. for 8″·8	3·08894
	4·64722		4·08295
Part.	0″·3	Part.	0″·9

Hence moon's semidiameter ..... = 14′ 54″·1
Moon's horizontal parallax ..... = 54 33·8
Augmentation ..... = 0 11·3
Hence semidiameter ..... = 15 5·4

Observed altitude		51°	30′ 20″
Index correction	+	0	2 20
		54	32 40
Dip	−	0	4 24
		54	28 16
Semidiameter		0	15 5·4
Apparent altitude		54	43 21·4
Correction in altitude		0	30 30
		0	0 19
True altitude		55	14 10·4

Chap. III.—ON FINDING THE LATITUDE.

Sect. I.—Of finding the latitude by meridian altitudes.

1. *By a single Meridian Altitude above the Pole.*

Subtract the true meridian altitude (corrected from observed meridian altitude) from 90°; the result is the zenith distance—which mark N. or S., according as the zenith is north or south of the observed heavenly body: find also the declination, which must be marked N. or S. If the zenith distance and the declination have the same name, their sum will be the latitude, with the name of either. If they be of different names, take their difference, which will be the latitude, with the name of the greater.

Finding the Latitude.

The process will differ in detail, according to the nature of the body observed.

(1.) If it be a fixed star, the altitude must be corrected only for index correction, dip, and refraction; and the declination is given at once by the tables.

(2.) If it be a planet, the declination must be corrected by getting a Greenwich date, applying the proportional increase or decrease for this date. If great accuracy is required, the semidiameter and horizontal parallax must also be found, and the altitude corrected for these.

(3.) If it be the sun, the Greenwich date must be got, and the declination corrected for this; the altitude must be corrected for index, dip, semidiameter, refraction, and parallax.

(4.) If it be the moon, a Greenwich date must be got. If it be only known that the observed altitude is a meridian altitude, the meridian passage at Greenwich must be corrected for the longitude, and the Greenwich date obtained by applying the longitude in time as already shown. Th moon's semidiameter, horizontal parallax, and declination, must be corrected for the Greenwich date, and the true altitude and declination thus found. When the true altitude and declination are found, the remainder of the process is according to the rule given above, and is the same for all.

Ex. 1.—May 20, 1857, the observed meridian altitude of Castor was 49° 20′ 30″ (zenith N. of star), the index correction was − 3′ 40″, and the height of the eye above the sea was 18 feet; required the latitude.

Observed altitude		49°	20′ 30″
Index error	−	0	3 40
		49	16 50
Dip	−	0	4 11
		49	12 39
Correction for refraction	−	0	0 50
True altitude		49	11 49
		90	0 0
Zenith distance		40	48 11 N.
From *Nautical Almanac*, declin. of Castor α^2 Geminorum on May 20		32	12 1·7 N.
Latitude		73	0 12 N.

Ex. 2.—October 10, 1857, the observed meridian altitude of α Ophiuchi was 54° 20′ 30″ (zenith, N. of the star), the index correction was − 3′ 20″, and the height of the eye above the sea was 16 feet; required the latitude.

Observed altitude		54°	20′ 30″
Index correction	−	0	3 20
		54	17 10
Dip	−	0	3 56
		54	13 14
Correction in altitude	−	0	0 42
		54	12 32
		90	0 0
Zenith distance		35	47 28 N.
Declination of α Ophiuchi		12	40 2·4 N.
Latitude		48	27 30·4 N.

Ex. 3.—January 6, in Long. 59° 30′ E., the observed meridian altitude of the sun's lower limb was 60° 20′ 30″ (zenith N. of the sun), the index correction was + 4′ 10″, and the height of the eye above the sea was 10 feet; required the latitude.

January 6, ship ..... $0^h\ 0^m\ 0^s$
Longitude ..... 3 58 0 E.

Greenwich, January 5 ..... 20 2 0

Sun's declination, Jan. 5 ..... 22° 35′ 43″·6 S.
„ „ 6 ..... 22 28 35·9
Diff. ..... 0 7 7·7

·07846
1·40309
1·48146 Part. 0 6 6

True declination ..... 22 29 37·6 S.

Sun's semidiameter ..... 16′ 18″·2

Finding the Latitude.

Observed altitude	60°	20′	30″
Index	+0	4	10
	60	24	40
Dip	−0	3	7
	60	21	33
Semidiameter	0	16	18·2
	60	37	51·2
Correction in altitude	−0	0	28
	60	37	23·2
	90	0	0
Zenith distance	29	22	36·8 N.
Declination	22	29	37·6 S.
Latitude	6	52	59·2 N.

Ex. 4.—April 4, in Long. 55° 20′ E., the observed meridian altitude of the moon's lower limb was 58° 40′ 10″ (zenith S. of the moon), the index correction was +3′ 20″, and height of the eye above the sea was 9 feet; required the latitude.

Moon's meridian passage, April 4	9ʰ	0ᵐ·5	
„ „ 3	8	13·4	
	0	47·1	
Correction	0	7·0	
Meridian passage (ship)	8	53·5 =	8ʰ 53ᵐ 30ˢ
Longitude			3 41 20 E.
Ship, April 4			5 12 10

	Moon's Semidiameter.	Horizontal Parallax.	Declination.
Ap. 4, Noon	15′ 14″·9	55′ 49″·7	5ʰ ... 17° 25′ 42″·6 N.
Mid ...	15 10·4	55 33·4	6 ... 17 13 19·4
Diff.	0 4·5	0 16·3	0 12 23·2

·36318	·36318	·69298
3·38021	2·82124	1·16243
3·74339	3·18442	1·85541

Part	0	2	
Semi	15	12·9	
Augmentn.	0	12·9	
Semidiam.	15	25·8	

Part	0	7·1	
H.P.	55	42·6	

Part	0	0	2·31
Decln.	17	23	11·6 N.

Observed altitude	58°	40′	10″
Index	+ 0	3	20
	58	43	30
Dip	− 0	2	57
	58	40	33
Semidiameter	0	15	25·8
	58	55	48·8
Correction	0	27	49
	0	0	21
	59	23	58·8
	90	0	0
	30	36	1·2 S.
Declination	17	23	11·6 N.
Latitude	13	12	49·6 S.

2. *By a single Observed Altitude below the Pole.*

Rule.—Correct the altitude, and to it add 90°, and from this sum subtract the declination; the remainder is the latitude.

Ex. 1.—June 4, 1857, the observed meridian altitude of β Chamæleontis, under the S. pole, was 29° 56′ 40″, the index correction was −2′ 40″, and the height of the eye above the sea was 15 feet; required the latitude.

Observed altitude	29°	56′	40″
Index correction	−0	2	40
	29	54	0
Dip	−0	3	49
	29	50	11
Correction in altitude	−0	1	41
True altitude	29	48	30
	90	0	0
	119	48	30 S.
Declination of β Chamæleontis	78	31	30 S.
Latitude	41	17	0 S.

Ex. 2.—Nov. 20, 1857, the observed meridian altitude of ν Draconis under the N. pole, was 31° 40′ 20″, the index correction was +1′ 20″ and the height of the eye above the sea 20 feet; required the latitude.

Finding the Latitude.

Observed altitude	31°	40′	20″
Index	+0	1	20
	31	41	40
Dip	−0	4	24
	31	37	16
Correction in altitude	−0	1	34
True altitude	31	35	42
	90	0	0
	121	35	42 N.
Declination ν Draconis, Nov. 10	61	50	9 N.
Latitude	59	45	33 N.

In the following example, the altitude is observed by means of an artificial horizon.

June 8, 1857, in Long. 1° 6′ W., the observed altitude of the sun's lower limb (in quicksilver horizon) was 121° 9′ 4″, index correction 1′ 20″; required the latitude.

Ship, June 8	0ʰ	0ᵐ	0ˢ
Longitude	0	4	24 W.
Greenwich, June 8	0	4	24

Sun's declination, June 8	22°	52′	43″ N.
„ „ 9	22	57	50·8
2·5 5630	0	0	7·8
1·54487			
4·09117	0	0	0·9
Sun's declination	22	52	43·9 N.

Semidiameter ..... 15′ 47″·3

Observed altitude	121°	9′	40″
Index	−0	1	20
	2)121	8	20
	60	34	10
Semidiameter	0	15	47·3
	60	49	57·3
Correction in altitude	−0	0	28
True altitude	60	49	29·3
	90	0	0
Zenith distance	29	10	30·7 N.
Declination	22	52	43·9 N.
Latitude	52	3	14·6 N.

SECT. II.—BY OBSERVED ALTITUDES OUT OF THE MERIDIAN.

1. *By Observations of the Altitude of the Pole-Star (α Polaris).*

The tables for this purpose are given in the *Nautical Almanac*, pp. 513 to 515.

Rule.—From the observed altitude, corrected for the error of the instrument, refraction, and dip of the horizon, subtract 2′.

Reduce the mean time of observation at the place to the corresponding sidereal time.

With the sidereal time found, take out the *first correction* with its proper sign. If the sign be +, the correction must be added to the reduced altitude; but if it be −, it must be subtracted; in either case the result will give an approximate latitude.

With the altitude and sidereal time of observation, take out the *second correction*; and with the day of the month and the same sidereal time, take out the *third correction*. These two corrections, added to the approximate latitude, will give the latitude of the place.

Ex.—January 20, 1857, at 9ʰ 40ᵐ P.M. (mean time nearly), in Long. 30° 20′ E., the observed altitude of Polaris was 31° 40′ 20″, the index correction was −2′ 20″, and height of the eye above the sea, 10 feet; required the latitude.

Ship, Jan. 20	9ʰ	40ᵐ	0ˢ
Longitude	2	1	20 E.
Greenwich, Jan. 20	7	38	40

Finding the Latitude.

Sidereal time at mean noon, Greenwich, Jan. 20	19h	59m	14s·42
Acceleration for 7h 39m	0	1	15
Mean time at place	9	40	0
Sidereal time	5	40	29·42
Observed altitude	31°	40′	20″
Index	− 0	2	20
	31	38	0
Dip	− 0	3	7
	31	34	53
Correction in altitude	− 0	1	34
True altitude of Polaris	31	33	19
	− 0	2	0
Reduced altitude	31	31	19
With argument 5h 40m (*first cor.*)	− 0	32	13
Approximate latitude	30	59	6
Arguments 30° / 5h 40m (*second cor.*)	− 0	0	31
Arguments, Jan. 20, 1857, 5h 40m (*third cor.*)	0	2	16
Latitude	31	1	53 N.

3. *By Observed Altitudes of a Heavenly Body very near the Meridian.*

The sun is the body most usually observed for the purpose. The apparent time from noon or hour angle is supposed to be known; as also the latitude by account, which is supposed to differ from the true latitude only by a small quantity.

Rule.—Add together the tabular logs. of cosines of the latitude by account, and of the declination of the observed body. To these add log. rising, if a table of log. rising be used; or, 6·301030 + log. haversine hour angle, if a table of haversines be used; or twice the log. sine of half the hour angle with the same constant log., if a table of log. sines only be used.

In all cases cast out the tens from the result, and the remainder is the logarithm of a natural number, which, added to the natural sine of the true altitude, will give the natural cosine of the meridian zenith distance. The declination applied to this—as already pointed out in preceding problems—will give the latitude. The hour angle in this rule must be found by applying to the mean time at the ship the equation of time corrected for the Greenwich date.

If the latitude thus found differ much from the latitude by account, the work must be repeated, using the latitude found instead of latitude by account.

Ex.—October 11, 1857, in Long. 114° E., and Lat. by account 46° 10′ N., the chronometer showed 4h 38m 10s, being slow on Greenwich 14m 10s. The altitude of the sun's lower limb was observed to be 36° 35′ 20″, the index error was −2′ 20″, and the height of the eye above the sea 16 feet; required the latitude.

Chronometer	4h	38m	10s
Error (slow)	0	14	10
	4	52	20
	12	0	0
Green., Oct. 10	16	52	20

Sun's declination, October 10	6°	44′	0″·9
„ 11		6	43·5
·15318	0	21	42·6
·91843			
1·07166	0	14	59
Declination S.	6	58	59·9
Semidiameter	0	16	4
Lat. by acct.	46	10	0
Declination	6	58	57·9
Log.	0	41	30·61

Equation of time, October 10 +	0h	12m	59·81
„ 11	0	13	15·15
	0	0	15·34
·15318			
2·84873			
3·00191	0	0	10·3
Equa. of time	0	13	10·61
Chron. showed	4	38	10
Error (slow)	0	14	10
Greenw. m. t. 12 +	4	52	20
Longitude	7	36	0 E.
	24	28	20
Equation of time	0	13	10·61
Hour angle	0	41	30·61
L cosine			9·840459
L cosine			9·996766
			19 837225
Log. rising			3·213724
			3·050949

Nat. number by table of log. rising, 1124.

Or			19·837225
Hour angle 41m 30s·61, log. haversine			7·912484
Constant log.			6·301030
Natural number, 1124			3·050739
Or			19·837225
Half-hour angle, 20m 45″·3, 2 log. sin.			17·912484
Constant log.			6·301030
Natural number, 1124			3·050739

Observed altitude	36°	35′	20″	
Index correction	− 0	2	20	
	36	33	0	
Dip	0	3	56	
	36	29	4	
Semidiameter	0	16	4	
	36	45	8	
Correction in altitude	0	1	11	
	36	43	57	Nat. sine 597080
				1124
Mer. zen. dist.	53°	16′	11″ N.	Nat. cosine 598204
Declination	6	59	0 S.	
True lat.	46	16	11 N.	

Finding the Latitude.

4. *By two Observed Altitudes of the Sun, and the Time between; having given also the Latitude by Account (Douwe's Method).*

Rule.—To find the hour angle corresponding to the greater meridian altitude—*i.e.*, the hour from apparent noon, at which the greater altitude is observed.

To the log. secant of the latitude by account, add the log. secant of the sun's declination (the mean between the declinations at the first and second observation); this, rejecting 20, is called the logarithm ratio. To this add the log. of the difference of the natural sines of the two altitudes, and the logarithm of the half-elapsed time from the proper column (taken from nautical tables, which are furnished with special tables for this purpose).

Find this sum in the column of middle times, and take out the time answering thereto; the difference between this and the half-elapsed time will be the time from noon, when the greater altitude was observed.

Or from any table:—

Find the logarithm ratio as before.

Subtract each of the true altitudes from 90°, to get the true zenith distances, and take half their sum and half their difference; and to the logarithm ratio add the sum of the log. of the sines of this semi-sum and semi-difference, and from this sum subtract the log. sine of the half-elapsed time; the remainder is the log. sine of middle time, which find from a table of log. sines, and the difference of the middle time and half-elapsed time is the time from noon, at which the greater altitude is observed.

We have now an observed altitude and the time from noon or hour angle corresponding; the remainder of the solution is therefore the same as in the last case, except that the log. ratio, being the sum of the logarithms of the secants, may be used instead of the sum of the logarithms of the cosines, with the negative sign. If the latitude so found differs much from the latitude by account, the work must be repeated, using the computed latitude for the latitude by account.

This rule is only approximate, and must be used under the following restrictions:—1. The observations must be taken between nine in the forenoon and three in the afternoon. 2. If both the observations be made in the forenoon, or both in the afternoon, the interval must not be less than the distance of the time of observation of the greatest altitude from noon. 3. If one observation be in the forenoon and the other in the afternoon, the interval must not exceed $4\frac{1}{2}$h; and in all instances the nearer to noon the greater altitude is observed the better. 4. If the sun's meridian zenith distance be less than the latitude, the limitations are still more con-

Finding the Latitude.

tracted. If the latitude be double the meridian zenith distance, the observations must be taken between half-past nine in the morning and half-past two in the afternoon; and the interval must not exceed $3\frac{1}{2}^h$. The observations must be taken still nearer to noon if the latitude exceed the zenith distance in a greater proportion.[1]

As the ship is generally in motion between the two observations, it is necessary to apply to the first altitude a correction for its run in the interval, so as to obtain what the altitude would have been if observed at the same time as the second.

If θ be the angle between the course of the ship and the bearing of the sun, the correction for run is $y = \pm m \cos \theta$, where m is the number of minutes in the angle subtended by the ship's run,—*i.e.*, number of miles run,—and θ the angle between the bearing of the sun and the course; and the sign + or − is to be used according as the ship is moving towards or from the heavenly body: in the former case θ is less than 90°, and in the latter greater. It is evident, from the form of the expression, that this correction may be found in a traverse table by looking out the difference between the course and bearing, or what it wants of 8 points for a course, and the ship's run as a distance; the corresponding difference of latitude, multiplied by 60, will then be the number of seconds in the correction for run, which is to be added or subtracted according as the angle is less or greater than 8 points or 90°. Thus, the bearing of the sun was S.E., the run was S.S.E. 18 miles; required the correction for run. Here the angle between the bearing and the course is 2 points, and the distance 18 miles; on entering a traverse table with these, we find the true difference of latitude 16·6. Hence the correction for run is +16′ 12″.

Ex.—April 20, 1857, in Lat. 44° 20′ N., Long. 35° 50′ E., the following double altitude of the sun was observed:—

Mean Time, nearly.	Chronometer.	Obs. Alt. Sun's L.L.	True Bearing.
$10^h\ 40^m$ A.M.	$8^h\ 30^m\ 20^s$	53° 5′ 45″	S.E. by S.
2 40 P.M.	0 29 40	41 0 30	S.W. by W.

The run of the ship in the interval was S.S.E. 25 miles, the index correction was −4′ 40″, and the height of the eye above the sea 15 feet; required the true latitude at the last observation.

The angle between the true bearing at first observation and ship's course is 1 point; the true difference of latitude, corresponding to distance 25 and course 1 point in traverse table, is 24′·5. Hence correction for run to be applied to the greater altitude is +24′ 30″.

First observation—
Ship, April 19, $22^h\ 40^m\ 0^s$
Longitude ..... 2 23 20 E.
Greenw., Ap. 19, 20 16 40

Second observation—
Ship, April 20, $2^h\ 40^m\ 0^s$
Longitude ..... 2 23 20 E.
Greenw., Ap. 20, 0 16 40

	Sun's Declin.	Semidiam.	Sun's Declin.	Semidiam.
April 19	11° 15′ 16″·7	15′ 56″·9	11° 35′ 53″·8	15′ 56″·6
„ 20	11 35 53·8		11 56 19·6	
	0 20 37·1		0 20 15·8	
	·07319	1·93668		
	·94105	·94849		
	1·01424	2·88517	0 0 14·1	
	0 17 25			
True decl.,	11 32 41·9	True decl.,	11 36 7·9	
	11 36 7·9			
	2)23 8 49·6			
	11 34 24·8 mean declination.			

First obs. alt.	53° 5′ 45″	Second obs. alt.	41° 0′ 30″
Index	−0 4 40	Index	−0 4 40
	53 1 5		40 55 50
Dip	−0 3 49	Dip	0 3 49
	52 57 16		40 52 1
Semidiameter	+0 15 56·9	Semidiameter	0 15 56·6
	53 13 12·9		41 7 57·6
Cor. in alt.	−0 0 38	Cor. in alt.	0 1 0
	53 12 34·9	True alt.	41 6 57·6
Cor. for run	+0 24 30		
True alt.	53 37 4·9		

Finding the Latitude.

Lat. by acct. N. 44° 20′ 0″ Log. secant ..... ·145520
Mean declin. S. 11 34 24 Log. secant ..... ·008947
Log. ratio ..... ·154467

Greater alt., 53° 37′ 4″·9 Nat. sine, 80508
Less alt. .... 41 6 57·6 „ 65758
Diff. ..... 14850 Log. ..... 4·171726
Log. ratio, 0·154467

Chronometer .... $12^h\ 29^m\ 40^s$
„ 8 30 20
2)3 59 20 Elapsed time.
1 59 40 Half elapsed time ..... 0·30213
0 49 4 Middle time ..... 4·62832
1 10 36 Time from noon at which greater altitude is observed.
Log. rising ..... 3·67277
Log. ratio ..... ·154467
3·518303

Nat. number..... 3298
Nat. sine gr. alt.. 80508
83806 Nat. cos. .... 33° 3′ 48″ N. mer. zen. dist.
11 32 41 decl. at greater alt.
Approx. lat. 44 36 9

Latitude..... 44° 36′ 9″ Log. secant ..... ·147522
Declination .... 11 34 24·8 Log. secant ..... ·008947
Log. ratio ..... ·156469

Diff. nat. sine... ·14850 Log. ..... 4·171726
Log. ratio ..... ·156469
$1^h\ 59^m\ 40^s$ Half-elapsed time .... ·30213
0 49 18 Middle time..... 4·63032
1 10 22 Time from noon at which greater altitude is observed.
Log. rising ..... 3·67196
Log. ratio..... ·15647
3·51449

Nat. number... 3269
N. sine gr. alt... 80508
83777 Nat. cosine... 33° 5′ 40″ N. mer. zen. dist.
11 32 41 sun's decl.
True lat., 44 38 21 N.

Or, if a table of logarithmic sines, &c., only be used, we have—

1st true corrected alt...	53° 37′ 4″·9	2d true alt...	41° 6′ 57″·6
	90 0 0		90 0 0
Zenith dist.	36 22 55·1		48 53 2·4
	48 53 2·4		
	2)85 15 57·5		
Semi-sum zenith dist. ...	42 37 58·7	Log. sine	9·830813
	2)12° 30′ 7″·3		
Semi-difference	6 15 3·6	Log. sine	9·036953
		Log. ratio	·154467
			19·022233
Half-elapsed time	$1^h\ 59^m\ 40^s$	Log. sine	9·697874
	0 48 44		9·324359
	2)1 10 56		
Half-hour angle ...	0 35 28	2 log. sine	18·375806
		Constant log....	6·301030
			24·676836
		Log. ratio	·15647
			4·520366

Nat. number..... 3314
Nat. sine gr. alt... 80508
83822 Nat. cosine .. 33° 2′ 48″ mer. zen. dist.
Decl. 11 32 41
Approx. lat. 44 35 29

Similarly, by taking this approximate latitude, we shall get the true latitude, 44° 38′ nearly, as before.

[1] See Mackay's Treatises on *Longitude* and *Navigation*, &c.; *Requisite Tables*, 3d edition; Mendoza Rios's *Tables*; Norie's and Riddle's Treatises on *Navigation*, &c.

Finding the Latitude.

5. *By any Two Altitudes of the same or different Heavenly Bodies, and the Polar Angle between them.*

In this case the declinations of the heavenly body or bodies at the two observations are supposed to be known.

If the same body be observed at different times, the polar angle is the elapsed time measured sidereally, if necessary. If different bodies be observed *at the same time*, this angle is the difference of their right ascensions.

If different bodies be observed, but not at the same time, to the right ascension of the first observed body, add the elapsed time measured sidereally, and the difference between this sum and the right ascension of the second observed body is the polar angle required.

The polar angle being given, the following rule will give the latitude:—

(1.) If the sun be the body observed: from the declination find the polar distance by subtracting it from 90°, if of the same name with the latitude; and adding it, if of an opposite name.

Add together log. sine polar distance at the greater bearing, log. sine polar distance at lesser bearing, and log. haversine of polar angle; reject 10 from the index; the result is the haversine of an arc, which look out, and call arc (1).

(2.) If two stars be observed: find the polar distances; add together log. sine polar distance at greater bearing, log. sine polar distance at lesser bearing, and log. haversine of the polar angle; the result is the haversine of an arc, which find from the table, and add its versed sine to the versed sine of the difference of the polar distances; the result is the versed sine of an arc, which is arc (1), as before.

Find the difference of the polar distances, and take the difference and the sum of this quantity and of arc (1). Add together log. cosecants of the arc (1) and of polar distance at greater bearing, and the halves of the log. haversines of the two arcs just obtained; the sum, rejecting 10 in the index, is the log. haversine of an arc, which take from tables, and call arc (2).

Again, take the difference of arc (1) and the zenith distance at greater bearing, and take the sum and difference of this arc and the zenith distance at less bearing. Add together log. cosecants of arc (1) and of zenith distance at greater bearing, and the halves of the log. haversines of the arcs just found; and the result, rejecting 10 in the index, is the log. haversine of an arc, which call arc (3).

Arc (4) is the difference between arc (2) and arc (3); or the sum if the arc joining the heavenly bodies at the two observations passes between the zenith and the pole.

Add together log. sine polar distance at greater bearing, log. sine zenith distance at greater bearing, and log. haversine arc (4); the sum, rejecting 10 in the index, is the log. haversine of an arc, which call arc (5).

Add together versed sine of the difference of the zenith distance and polar distance at greater bearing, and the versed sine of arc (5). The result is the versed sine of the co-latitude. Find this from the tables, subtract it from 90°; and the result is the latitude.

This method of finding the latitude, which is at once the most general and accurate, is due to the Rev. Dr Inman, to whose excellent work on Navigation the reader is referred for further information respecting it.

Ex. 1.—March 25, 1857, in Lat. 54° 47′ N., and Long. 98° E., the following double altitude of the sun was observed:—

Mean time, nearly.	Chronometer.	Obs. Alt. L. L.	Bearing.
9h 30m A.M.	10h 26m	26° 0′ 40″	S.E.
1 45 P.M.	2 39	84 6 20	S.W. by S.

The run of the ship in the interval was S.S.E. 18 miles, the index correction was +2′ 10″, and the height of the eye above the sea was 18 feet; required the latitude at the last observation.

Ship, March 24.....21h 30m	Ship, March 25..... 1h 45m
Longitude..... 6 32 E.	Long..... 6 32 E.
Greenwich, Mar. 24, 14 58	Greenwich, Mar. 24, 19 13

Sun's declination,		Sun's declination,	
March 24	1° 30′ 57″·2	March 24.....	1° 30′ 57″·2
„ 25	1 54 32·9	„ 25.....	1 54 32·9
Diff.	0 23 35·7	Diff.	0 23 35·7
·20509		·09653	
·88236		·88236	
1·08745 Part.	0 14 43	·95889 Part.	0 18 54
T. dec. gr. bearing	1 45 40·7 N.	Dec. less bear.	1 49 51·2
	90 0 0		90 0 0
P. dis. gr. bearing	88 14 19 3	P. dis. less. bear.	88 10 8·8

Sun's semidiameter..... 16′ 14″

Sun's altitude at gr. bearing.		Sun's altitude at lesser bearing.	
Obs. alt.....	26° 0′ 40″	Obs. altitude.....	34° 6′ 20″
Index correction	+0 2 10	Index correction	+0 2 10
	26 2 50		34 8 30
Dip.....	−0 4 11	Dip	−0 4 11
	25 58 39		34 4 19
Semidiameter...	0 16 4	Semidiameter...	0 16 4
	26 14 43		34 20 23
Cor. in alt. for refr. and parallax	−0 1 50	Cor. in altitude	−0 1 18
	26 12 53	True altitude....	34 19 5
Cor. for run.....	+0 16 36		90 0 0
True altitude...	26 29 29	Zen. dis. less. bear.	55 40 55
	90 0 0		
Zen. dis. gr. bear.	63 30 31		

To find arc (1).

P. dist. gr. bearing	88° 14′ 19″·3	L sin.....	9·999794
P. dist. less. bear.	88 10 8·8	L sin.....	9·999778
Chronometer.....	10h 26m		
	14 39		
	4 1·3	Elapsed time or polar angle.	
		L haversine.....	9·439255
		L haversine arc (1)...	9·438827
Arc (1).....	63° 12′ 52″		

To find arc (2).

Arc (1).....	63° 12′ 52″	Log. cosec.....	·049296
P. dist. gr. bear.	88 14 19·3	Log. cosec.....	·000206
Difference	25 1 26·7		
P. dist. less. bear....	88 10 8·8		
Sum	113 11 35·5	½ log. haversine....	4·921790
Difference	63 8 42·1	½ log. haversine....	4·718970
		Log. haversine arc (2)...	9·690062
Arc (2).....	88° 50′ 12″		

To find arc (3).

Arc (1).....	63° 12′ 52″	Log. cosec.....	·049296
Zen. dist. gr. bear.	63 30 31	Log. cosec.....	·049176
Difference.....	0 17 39		
Zen. dist. less. bear.	55 40 55		
Sum	55 58 34	½ haversine	4·671438
Difference	55 23 16	„	4·667217
		Log. haversine arc (3)	9·436127
Arc (3).....	62° 59′ 48″		

To find arc (4).

Arc (2).....	88° 50′ 12″
Arc (3).....	62 59 48
Arc (4).....	25 50 24

To find arc (5).

P. dist. gr. bearing...	88° 14′ 19″·3	L sin.....	9·999794
Zen. dist. „ ...	63 30 31	L sin.....	9·951824
Difference	24 43 48·3	Log. haversine.....	8·698906
		Log. haversine arc (5).....	8·650524
Arc (5).....	24° 9′ 12″		

Nat. ver. sine	24° 9′ 19″	= 0089450
Nat. ver. sine	24 43 48·3	= 0091710
Nat. vers. colatitude		= 0181160
Colatitude	35° 1′ 16″	
	90 0 0	
Latitude	54 58 44	

Finding the Longitude.

Ex. 2.—Nov. 30, 1857, in Lat. by account 30° N., the following altitudes of stars were taken at the same time; required the true latitude.

True alt. β Orionis.	Bearing.	True alt. α Hydræ.	Bearing.
42° 45′ 15″.	S.W.	39° 35′ 15″	S.S.E.

From *Nautical Almanac* we find—

β Orionis, R.A.	5h 7m 44s	Declination, S.	8° 21″ 57″
			90 0 0
		N. P. D. at G. B.	98 21 57
α Hydræ, R. A.	9 20 36	Declination S.	8 2 30
Polar angle	4 12 52		90 0 0
		N. P. D. at L. B.	98 2 30
P.D. at G. B.	98 21 57	L sine	9·995353
„ L. B.	98 2 30	L sine	9·995708
„ Diff.	0 19 17	Haversine polar angle	9·438871
		Haversine	9·429932

Arc ..... 62° 29′ 58″.

Nat. ver. sine ..... 62° 29′ 58″ = 0537993
248

Nat. ver. sine ..... 0 19 17 = 0000015

Nat. ver. sine arc (1) 0538256

Arc (1)..... 62° 30′ 1″.

To find arc (2).

Arc (1)	62° 30′ 1″	Log. cosec	·052069
P. D. at G. B.	98 21 57	„	·004646
Diff.	35 51 56		
P. D. at L. B.	98 2 30		
Sum	133 54 26	½ haversine	4·963876
Diff.	62 10 34	„	4·712946
		Haversine arc (2)	9·733537

Arc (2)..... 94° 45′ 8″.

To find arc (3).

True alt. at G. B.	42° 45′ 15″		
	90 0 0		
Z. D. at G. B.	47 14 45		
True alt. at L. B.	39 35 15		
	90 0 0		
Z. D. at L. B.	50 24 45		
Arc (1)	62° 30′ 1″	Log. cosec	·052069
Z. D. at G. B.	47 14 45	„	·134142
Diff.	15 15 16		
Z. D. at L. B.	50 24 45		
Sum	65 40 1	½ Haversine	4·734159
Diff.	35 9 29	„	4·480037
		Haversine arc (3)	9·400407

Arc (3) ..... 60° 11′ 18″.

To find arc (4).

Arc 2	94° 45′ 8″
Arc 3	60 11 18
Arc (4)	34 33 50

To find arc (5).

P. D. at G.B.	98° 21′ 57″	L sine	9·995354
Z. D. at G.B.	47 14 45	„	9·865858
Diff.	51 7 12	Haversine arc (4)	8·945729
		Log. haversine arc (5)	8·806941

Arc (5)..... 29° 20′ 4″.

Nat. ver. sine..... 51° 7′ 12″=0372263
45

„ ..... 29 20 4 =0128226

Nat. ver. sine, colatitude..... 0500534

Colat..... 60° 2′ 7″
90 0 0

Lat. N. 29 57 53

Chap. IV.—ON FINDING THE LONGITUDE BY OBSERVATION.

Sect. I.—Introduction.

The observations necessary to determine the longitude by this method are the altitudes of the sun or other heavenly body, or the distance between the sun and moon, the moon and a planet, or the moon and a fixed star near the ecliptic, together with the altitude of each. The planets used in the *Nautical Almanac* for this purpose are the following:— Venus, Mars, Jupiter, and Saturn. The stars are, α *Arietis*, *Aldebaran*, *Pollux*, *Regulus*, *Spica Virginis*, *Antares*, α *Aquilæ*, *Fomalhaut*, and α *Pegasi*; and the distances of the moon's centre from the sun, and from one or more of these planets and stars, are contained in the xiii. to xviii. pages of the month, at the beginning of every third hour mean time by the meridian of Greenwich. The distance between the moon and one of these objects is observed with a sextant; and the altitudes of the objects are taken as usual with a sextant or a Hadley's quadrant.

Finding the Longitude.

In the practice of this method it will be found convenient to be provided with three assistants. Two of these are to take the altitudes of the sun and moon, or moon and star, at the same time that the principal observer is taking the distance between the objects; and the third assistant is to observe the time, and write down the observations. In order to obtain accuracy, it will be necessary to observe several distances, and the corresponding altitudes, the intervals of time between them being as short as possible; and the sum of each divided by the number will give the mean distance and mean altitudes; from which the time of observation at Greenwich is to be computed by the rules to be explained.

If the sun or star from which the moon's distance is observed, be at a proper distance from the meridian, the time at the ship may be inferred from the altitude observed at the same time with the distance. In this case the chronometer is not necessary; but if that object be near the meridian, the chronometer is absolutely necessary, in order to connect the observations for ascertaining the mean time at the ship and at Greenwich with each other.

An observer without any assistants may very easily take all the observations, by first taking the altitudes of the objects, then the distance, and again their altitudes, and reduce the altitudes to the time of observation of the distance; or, by a single observation of the distance, the time being known from which the altitudes of the bodies may be computed, the longitude may be determined.

A set of observations of the distance between the moon and a star or planet, and their altitudes, may be taken with accuracy during the time of the evening or morning twilight; and the observer, though not much acquainted with the stars, will not find it difficult to distinguish the star from which the moon's distance is to be observed. For the time of observation nearly, and the ship's longitude by account being known, the estimated time at Greenwich may be found; and by entering the *Nautical Almanac* with the reduced time, the distance between the moon and given star will be found nearly. Now set the index of the sextant to this distance, and hold the plane of the instrument so as to be nearly at right angles to the line joining the moon's cusps, direct the sight to the moon, and, by giving the sextant a slow vibratory motion, the axis of which being that of vision, the star, which is usually one of the brightest in that part of the heavens, will be seen in the transparent part of the horizon-glass.

Sect. II.—To find mean time by a single observation of the sun or moon, or other heavenly body.

Prob. 1.—Given the latitude of a place, the altitude, and declination of the sun, to find the true time and the error of the chronometer.

Rule.—If the latitude and declination are of different signs, take their sum; otherwise take their difference. From the natural cosine of this sum or difference, take the natural sine of the altitude (corrected); find the logarithm of the remainder, and to it add the log. secants of the lati-

Finding the Longitude.

tude and declination; the sum will be the log. rising of the horary distance of the sun from the meridian, and hence the apparent time will be known; by applying to it the equation of time, the mean time may be found, and the error of the chronometer.

Or, if a table of log. haversines be used, take the difference or sum of the latitude and declination as before. Under this difference place the zenith distance of the sun, and take their sum and difference.

Take the sum of half of the log. haversines of these quantities and of the log. secants of the latitude and declination; the result, rejecting the tens, is the log. haversine of the hour angle.

Or, if a table of sines only be used, add together one-half of the log. sines of half the arcs above found, of the log. secants of latitude and declination; the result is the log. sine of one-half the hour angle.

Ex.—March 25, 1857, at 3h 30m P.M. nearly, in Lat. 53° N., and Long. 35° 20′ W., when a chronometer showed 5h 46m 20s, the observed altitude of the sun's lower limb was 23° 12′ 10″, and the index correction was −4′ 20″, and the height of the eye above the sea 20 feet; required the true time, and error of chronometer.

Ship, March 25			3h 30m 0s
Longitude			2 21 20
Greenwich, March 25			5 51 20

Sun's declination,

March 25	1° 54′ 32″·9 N.	Sun's semidiam.	16′ 3″·7
„ 26	2 18 6	Equation of time	+6m 3s·20
Diff.	0 23 33·1	Diff. for 1h	0·767
			5
·61334			3·835
·88328		Diff. for 30m is ½	·383
1·49662	0 5 44	„ 20 is ⅓	·256
Sun's dec.	2 0 16·9	„ 1 is 1/20	·013
		„ 20s is ½	·004
		Equation, 5m 58s·703	= 4·491

Sun's obs. altitude		23° 12′ 10″
Index correction		− 0 4 20
		23 7 50
Dip		− 0 4 24
		23 3 26
Semidiameter		+ 0 16 3·7
		23 19 29·7
Correction in altitude		− 0 2 13
True altitude		23 17 16·7
		90 0 0
Zenith distance		66 42 43·3

Lat. N	53° 0′ 0″	Log. sec.	·220537
Declin. N.	2 0 16·9	„	·000266
Diff.	50 59 43·1		
Nat. cosine	0629380		
Nat. sin. 23° 17′ 16″,	0395349		
	0234031	Log.	4·369272
		Log. rising,	4·590075

Hour angle	3h 29m 24″
Equation of time	+0 5 59
Ship's mean time	3 35 23
Longitude	2 21 20
Greenwich mean time	5 56 43
Chronometer showed	5 46 20
	0 10 23

Or error of chronometer is 10m 23s slow on Greenwich.

Or—

Lat.	53° 0′ 0″ N.	Log. sec.	·220537
Declination	2 0 16·9 N.	Log. sec.	·000266
	50 59 43·1		
Zenith dist.	66 42 43·2		
Sum	117 42 26·3	½ haversine	4·932397
Diff.	15 43 0·1	„	4·135845
		Log. haversine hour angle	9·289045

Hour angle..... 3h 29m 24s, as before.

By taking another observation at the interval of a few days, the daily rate of the chronometer may be found.

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PROB. 2.—Given the latitude of a place, and the altitude of a known fixed star, to find the mean time of observation and error of chronometer.

The right ascension of the mean sun or sidereal time must be corrected for the Greenwich date of observation. The star's hour angle must then be found as in the last problem. To the hour angle thus found add the star's right ascension, and from the sum (increased, if necessary, by twenty-four hours) subtract the right ascension of the mean sun; the remainder is the mean time at the place at the instant of observation.

Ex.—January 16, 1857, at 8h P.M. (mean time, nearly), in Lat. 49° 57′ N., and Long. 32° 10′ W., when a chronometer showed 10h 23m 30s, the observed altitude of Regulus E. of meridian was 8° 20′ 30″, the index correction was −5′ 20″, and the height of the eye above the sea, 20 feet; required the mean time, and error of chronometer on Greenwich mean time.

Ship, Jan. 16	8h 0m 0s
Longitude	2 8 40 W.
Greenwich, Jan 16	10 8 40

Observed altitude	8° 20′ 30″
Index correction	−0 5 20
	8 15 10
Dip	−0 4 24
	8 10 46
Refraction	−0 6 27
True altitude	8 4 19
	90 0 0
True zenith distance	81 [illegible] 41

Star's right ascension	10h 0m 46s
Star's declination	12° 39′ 50″
Right ascension of mean sun	19h 43m 28s
Correction for 10h	0 1 38·6
„ 8m	0 0 1·3
„ 40s	0 0 0·1
True right ascension of mean sun	19 [illegible] s

Latitude	49° 37′ 0″ N.	Log. sec.	·188493
Declination	12 39 50 N.	Log. sec.	·010696
Diff.	36 57 10		
Zenith dist.	81 55 41		
Sum	118 52 51		
Half	59 26 25·5	Log. sin.	9·935054
Difference	44 58 31		
Half	22 29 15	Log. sin.	9·582611
			2 [illegible]
		Log. sin.	9·858427

Hence half hour angle	3h 4m 49s
	2
	6 9 38
	24 0 0
Star's hour angle	17 [illegible] 22
„ right ascension	10 0 46
	27 [illegible] s
Sun's right ascension	19 43 8
Ship's mean time	8 6 0
Longitude	2 8 40 W.
Greenwich mean time	10 [illegible] 40
Chronometer	10 23 30
Error (fast on Greenwich)	0 8 50

SECT. III.—TO FIND THE LONGITUDE BY MEANS OF A CHRONOMETER.

In order to find the longitude at sea by means of a chronometer, its daily rate in mean solar or sidereal time must be established by observations made at some particular place, and its error ascertained for the meridian of that or of any other known place.

An observatory is the most proper and convenient place for this purpose, as there the rate and error may be both determined with the utmost accuracy by equal altitudes, or transits over the meridian of the sun or stars. But if an observatory is not adjacent, the rate and error of the chronometer may be found by altitudes taken daily for several

Finding the Longitude.

days from the horizon of the sea, or by the method of reflection from an artificial horizon.

If by these observations the daily rate is found to be nearly the same,—that is, if the chronometer gains or loses nearly the same portion of absolute time daily,—it may be depended on for finding the longitude; but if its rate is unequal, it must be rejected, as the longitude inferred from it cannot be expected to be accurate.

It would be proper to have two chronometers, and that they should be wound up at different stated times of the day, so that if one should be found stopt, either through neglect in winding up or otherwise, it may be set by the other, observing to apply the former interval of time between them, and the change in their rates of going in that interval.

PROB.—To find the longitude of a ship at sea by a chronometer.

Let several altitudes of the sun or a fixed star or planet be observed, and find the true mean altitude; with which, and the ship's latitude, and declination of observed body, compute the mean time of observation as in sect. ii.

To the mean of the times of observation, as shown by the chronometer, apply the error and accumulated rate. Hence the mean time under the meridian of the place where the error and rate were established will be known; to which apply the difference of longitude in time between that place and Greenwich, and the mean time of observation under the meridian of Greenwich will be obtained. The difference between the time at the place of observation and that at Greenwich will be the longitude of the ship in time; and it is east or west according as the time is later or earlier than the Greenwich time.

Ex. 1.—May 30, 1857, at 3h P.M. (mean time nearly), in Lat. 30° 20′ S., and Long. by account 155° 10′ E., when a chronometer showed 4h 40m 50s, the observed altitude of the sun's L.L. was 22° 10′, the index correction was −7′ 10″, and the height of the eye above the sea was 20 feet; required the longitude.

On May 20 the chronometer was fast on Greenwich mean time 4m 50s, and its daily rate was 2s·5 losing.

Ship, May 30	3h 0m 0s
Longitude	10 20 40 E.
Greenwich, May 29	16 39 30
Chronometer daily rate	2s·5 losing
	9
	22·5
12h is ½	1·2
4h is ⅓	·4
30m is ½	·05
9m 36s is ⅓ nearly	·0166
Accumulated rate	24·1666
Chronometer showed	4h 40m 50s
	4 41 14·166
Original error (fast)	0 4 50
	4 36 24·17
	12 0 0
Greenwich mean time	16 36 24·17

Sun's declination,

May 29, N.	21° 39′ 43″·9
30	21 48 46·1
	0 9 2·2

Equation of time, *subtractive*—

	3m 1s·73
	2 54·19
	0 7·54

0·15967 / 1·25383 / 1·41350 → 0 6 57

0·15967 / 3·15836 / 3·31803 → 0 5·2

Sun's decl. at obs. 21 46 40·9 — Equation of time, 2 56·53

Sun's semidiameter, 15′ 48″·5.

Observed altitude	22° 10′ 0″
Index correction	0 7 10−
	22 2 50
Dip	0 4 24
	21 58 26
Semidiameter	0 15 48·5
	22 14 14·5
Correction in altitude	0 2 14−
	22 12 0·5

Latitude	30° 20′ 0″ S.	Log. secant	·063938
Declin.	21 45 18·2 N.	,,	·029140
	52 5 18·2		
Nat. cosine	52 5 18·2 = 61434·7		
Nat. sine	22 12 0·5 = 37784·1		
	23650·6	Log.	4·373831
		Log. rising	4·466909

Hour angle	3h 0m 3s
Equation of time	0 2 56
	2 57 7
Ship's mean time	24 0 0
	26 57 7
Chronometer	16 36 24·17
	10 20 42·83

Longitude 155° 10′ 42″·45 E.

Ex. 2.—August 20, 1857, at 0h 30m A.M. (mean time nearly), in Lat. 50° 20′ N., and Long. 142° 15′ E., when a chronometer showed 2h 41m 13s, the observed altitude of α Aquilæ, west of meridian, was 36° 59′ 50″, the index correction was +6′ 20″, and height of the eye above the sea 20 feet; required the longitude.

On August 4, at noon, the chronometer was slow on Greenwich mean time 17m 50s, and its daily rate was 4s·5 losing.

Ship, August 19	12h 30m 0s
Longitude	9 29 0 E.
Greenwich August 19	3 1 0
Interval 15d 3h — Daily rate	4·5
	15
	225
	45
	67·5
3h is ¼	·5
Accumulated rate	1 8
Chronometer showed	2 41 13
	2 42 21
Original error	0 17 50
Greenwich mean time	3 0 11

Observed altitude	36° 59′ 50
Index	0 6 20+
	37 6 10
Dip	0 4 24−
	37 1 46
Refraction	0 1 17−
True altitude	37 0 29
	90 0 0
True zenith distance	52 59 31

Right ascension of mean sun (sidereal time)—

Aug. 19	9h 51m 7s·80
Part for 3h	0 0 29·57
11s	0 0 0·03
	9 51 37·4

Star's right ascension	19h 43m 51s·33
Star's declination	8° 29′ 43″ N.

Latitude	50° 20′ 0″ N.	Log. secant	·194962
Declination	8 29 43 N.	Log. secant	·004791
	41 50 17		
Zenith dist.	52 59 31		
Sum	94 49 48		
Half	47 24 54	Log. sine	9·867039
Difference	11 9 14		
Half	5 34 37	Log. sine	8·987594
			2)19·054386
		Log. sine half-hour angle	9·527193

Half-hour angle	1h 18m 41s·6
	2
Hour angle	2 37 23·2
Star's right ascension	19 43 51·33
	22 21 14·53
Right ascension of mean sun	9 51 37·4
Ship, mean time	12 29 37·13
Greenwich	3 0 11
	9 29 26·13

Longitude 142° 21′ 31″ E.

Finding the Longitude.

SECT. IV.—TO FIND THE LONGITUDE BY MEANS OF A LUNAR DISTANCE.

PROB. 1.—Given the apparent distance between the moon and sun, or a fixed star or planet, and the apparent and true altitudes of these bodies, to find the true distance, or, as it is called, to clear the distance.

Rule 1. (Borda's method).—Add together the logarithmic cosines of the true altitudes, the logarithmic secants of the apparent altitudes, the logarithmic cosines of one-half the sum of the apparent altitudes and apparent distance, and of this last arc, less the apparent distance. From one-half of this sum subtract the logarithmic cosine of one-half of the true altitudes; the result, rejecting 10 in the index, is the logarithmic sine of an arc. Find the logarithmic cosine of this arc, and add to it the logarithmic cosines of one-half of the true altitudes; the result, rejecting 10 in the index, is the logarithmic sine of one-half of the true distance required. Or,—

Rule 2.—Find the auxiliary angle A (which is given in the nautical tables of Inman, Norie, Riddle, and others).

Take the versed sine of the difference of the true altitudes. To it add the versed sines of the sum and difference of the auxiliary angle A and the apparent distance; under the difference of the apparent altitudes place the auxiliary angle A, and take their sum and difference; add together the versed sines of these two arcs, and subtract from the former quantity; the result is the versed sine of the true distance.

Ex.—Required the true distance of the moon from the sun, having given—

App. alt. sun	34° 21′ 32″	True alt. sun	34° 20′ 14″
App. alt. moon	57 11 25	True alt. moon	57 40 11
App. distance of centres	35° 47′ 24″		

By *Rule* 1—

True alt. moon	57° 40′ 11″	L cos	9·728227
True alt. sun	34 20 14	L cos	9·916839
App. alt. moon	57 11 25	L sec	·266131
„ sun	34 21 32	L sec	·083267
	91 32 57		
App. distance	35 47 24		
	2)127 20 21		
	63 40 10	L cos	9·646941
	35 47 24		
	27 52 46	L cos	9·946353
			2)39·587758
			19·793879
Sum of true alt.	92° 0′ 25″		
Half	46 0 12	L cos	9·841746
		L sin	9·952133
	Arc	63° 35′ 10″	
L cos 63° 35′ 10″			9·648216
L cos 46 0 12			9·841746
L sin half true dist.			9·489962
	Half true distance	17° 59′ 37″	
		2	
	True distance	35 59 14	

Rule 2.—Auxiliary angle A (taken from the tables) being 60° 25′ 16″.

Moon's true alt.	57° 40′ 11″		
Sun's true alt.	34 20 14		
Diff.	23 19 57	Vers.	0081777
A	60 25 16		
App. distance	35 47 24		
Sum	96 12 40	Vers.	1108192
Diff.	24 37 52	Vers.	0090990
			1280969
App. alt. sun	34 21 32		
„ moon	57 11 25		
Diff.	22 49 53		
A	60 25 16		
Sum	83 15 9	Vers. 0882506	1090107
Diff.	37 35 23	Vers. 0207601	
True dist. 35° 59′ 18″.		Nat. vers.	0190862

PROB. 2.—To find the longitude by a lunar observation. Get a Greenwich date, and to this date take out the moon's horizontal parallax and semidiameter. Increase the semidiameter for the augumentation corresponding to the moon's altitude. Finding the Longitude.

Find the apparent and true altitudes of the centre of the moon and of the sun or star which is observed, and the apparent central distance. From these elements compute the true distance as in the last problem, and find the mean time at Greenwich corresponding to it, as shown in chap. ii., sect. iv., p. 38.

If the sun or star be not too near the meridian at the time of observation, compute the mean time at the ship from its altitude; if it be too near, compute the mean time from the moon's altitude. The difference between the mean times of observation at the ship and Greenwich will be the longitude of the ship in time, which is E. or W. according as the time at the ship is later or earlier than the Greenwich mean time.

Ex. 1.—January 3, 1857, at 2ʰ 30ᵐ P.M., in Lat. 49° 20′ N., and Long. 15° 40′ E., the following lunar was taken:—

	Obs. alt. Sun's L. L.	Obs. alt. Moon's L. L.	Obs. dist. N. L.
	24° 40′ 10″	21° 36′ 40″	90° 28′ 10″
Index error	+0 1 20	−0 1 10	0 1 20

Height of eye above the sea, 18 feet; required the longitude.

Ship, Jan. 3	2ʰ 30ᵐ 0ˢ		
Longitude	1 2 40 E.		Sun's Semidiameter.
Greenwich, Jan. 3	1 27 20		16′ 18″·2
Sun's declination.			Equation of time.
Jan. 3, S.	22° 48′ 38″·6		+4ᵐ 54ˢ·03
„ 4, S.	22 42 24·6		5 21·38
1·21885	0 6 14	1·21885	0 27·35
1·46055		2·59726	
2·67940	0 0 22·6	3·81611	1·7
	22 48 16		4 55·73
Moon's semi., 3, noon	16′ 9″·2	Moon hor. par.	59′ 8″·9
„ mid.	16 10·7	„	59 14·2
	0 1·5		0 5·3
·91782		·91782	
3·85733		3·30915	
4·77515	0 0·1	4·22697	0 0·7
	16 9·3		59 9·6
Aug.	0 6		
	16 15·3		

	Sun's Alt.	Moon's Alt.	Lunar Dis.
Obs. alt.	24° 40′ 10″	21° 36′ 40″	90° 28′ 10″
Ind. cor.	+0 1 20	− 0 1 10	+ 0 1 20
	24 41 30	21 35 30	90 29 30
Dip	0 4 11 −	− 0 4 11	Sun's semi. 0 16 18
	24 37 19	21 31 19	Moon's semi. 0 16 15
Semi	0 16 18	0 16 15	App. dis. 91 2 3
	24 53 37	21 47 34	
Cor. in alt.	0 1 57 −	+0 52 23	
		8	
True alt.	24 51 40	Tr. alt. 22 40 5	
	90 0 0		
	65 8 20 true zenith distance.		

Aux. angle A	60° 11′ 46″	
	0 0 2	
	0 0 0	
	60 11 48	

To find ship's mean time.

Sun's decl.	22° 48′ 16″ S.	Sec.	0 035348
Latitude	49 20 0 N.	Sec.	0·185981
	72 8 16		
Sun's zen. dist.	65 8 20		
Sum	137 16 36		
Half	68 38 18	Sin.	9·969089
Diff.	6 59 56		
Half	3 29 58	Sin.	8·785604
			2·18·97[illegible]
			9·488011

Finding the Longitude.

Half-hour angle.....1h 11m 39s·6
2
Hour angle.....2 23 19
Equation of time .....0 4 53·7+
Ship mean time.....2 28 12·7

To find Greenwich mean time.

Sun's true alt. ....24° 51′ 40″
Moon's true alt. 22 40 5
Diff. .... 2 11 35 Vers. 0000726
Apparent dist.....91 2 3 6
Auxiliary angle 60 11 48
Sum .....151 13 51 Vers. 1876447
120
Difference .....30 50 15 Vers. 0141338
Sun's appar. alt.....24 53 37 37
Moon's do.....21 47 34 2018674
Difference 3 6 3
Auxiliary angle.....60 11 48
Sum .....63 17 51 Vers. ..0550421
220
Difference.....57 5 45 Vers. ..0456581
183 1007405
(1.) True distance .....90° 38′ 44″ 1011269
(2.) Distance at noon.....89 52 28 054
(3.) Distance at 3 P.M.....91 30 14 215

Diff. (1.) and (2.), 0° 46′ 16″ Prop. log. ..... ·59000
„ (2.) and (3.), 1 37 46 „ ..... ·26508
Interval..... 1h 25m 11s ·32492
∴ Greenwich mean time 1 25 11
Ship mean time 2 28 13
Longitude..... 1 3 2
Or..... 15° 45′ 30″ E.

Ex. 2.—February 28, 1857, at 7h 40′ P.M., in Lat. 55°, and Long. 57° 20′ W., the following star lunar was taken :—

	Obs. Alt. Pollux E. of Mer.	Obs. Alt. Moon Lower Limb.	Obs. Dist. Further Limb.
	60° 10′ 0″	46° 10′ 0″	70° 40′ 20″
Index error	−0 2 10	+0 1 20	−0 3 10

The height of the eye above the sea was 20 feet; required the longitude.

Ship, Feb. 28..... 7h 40m 0s
Longitude ..... 3 49 20 W.
Greenwich, Feb. 28.....11 29 20

Right ascension of mean sun,
Feb. 28..... 22h 33m 0s·09 Star's R. A. ... 7h 36m 35s
Part for 11h ... 0 1 48·42 Declination....28 22 10 N.
„ 29m ... 0 0 4·76
„ 20s ... 0 0 ·05
22 34 53·32

Moon's semi. 28, noon... 16′ 23″·2 Hor. par. noon... 59′ 59″·8
„ mid... 16 20·0 „ mid... 59 48·3
0 3·2 0 11·5

·01911 ·01911
3·52827 2·97273
3·54738 Part 0 3·1 2·99184 Part 0 11·0
16 20·1 59 48·8
Aug. 0 12·5
16 32·6

Star's Altitude.		Moon's Altitude.		Apparent Distance.	
Obs. alt.	60° 10′ 0″	Obs. alt.	46° 10′ 0″	Obs.....	70° 40′ 20″
Inx. cor.	−0 2 10		+0 1 20		−0 3 10
	60 7 50		46 11 20		70 37 10
Dip	−0 4 24		−0 4 24	Semi.....	−0 16 32·6
App. alt.	60 3 26		46 6 56	App. dis..	70 20 37·4
Refr.	−0 0 34	Semi.	0 16 32·6		
True alt.	60 2 52	App. alt.	46 23 28·6		
	90 0 0	Cor. alt.	0 39 48		
			33		
T. Z. dis.	29 57 8	True alt.	47 3 49·6		

Auxiliary angle A..... 60° 23′ 38″
21
0
60 23 59

Variation of the Compass.

To find ship's mean time.

Star's dec..... 28° 22′ 10 N. Sec ..... 0·055565
Latitude ..... 55 0 0 N. Sec ..... 0·241409
Diff 26 37 50
Star's zen. dis. 29 57 8
Sum..... 56 34 58 Half havers... 4·675736
Diff. ..... 3 19 18 Half havers... 3·462142
Hav. hour angle 8·434852

Hour angle (E. M.) 22h 44m 1s
Star's R. A..... 7 36 35
30 20 36
R. A. mean sun..... 22 34 53
Ship mean time..... 7 45 43

To find Greenwich mean time.

Star's true altitude ..... 60° 2′ 52″
Moon's „ ..... 47 3 49·6
Diff. ..... 12 59 2·4 Vers..... 0025564
2
App. distance 70 20 37
A 60 23 59
Sum.....130 44 36 Vers..... 1652539
133
Diff ..... 9 56 38 Vers..... 0014991
30
1693259
Star's app. altitude..... 60 3 26
Moon's „ ..... 46 23 28·6
13 39 57·4
A 60 23 59
Sum..... 74 3 56·4 Vers. 0725202
261
Diff. ..... 46 44 1·6 Vers. 0314605
7
1040075
Vers. true distance 0653184

True distance ..... 69° 42′ 13″
Distance at 9h 71 16 1
„ midnight..... 69 27 42

First diff. ..... 1° 33′ 48″ Prop. log..... ·28307
Second ..... 1 48 19 Prop. log..... ·22058
·06149

Time from 9h 2h 36m 14s
9 0 0
Greenwich mean time 11 36 14
Ship mean time 7 45 43
3 50 31

Longitude...57° 37′ 45″ W.

Chap. V.—OF THE VARIATION OF THE COMPASS.

The variation of the compass is the deviation of the points of the mariner's compass from the corresponding points of the horizon, and is denominated *east* or *west* variation, according as the north point of the compass is to the east or west of the true north point of the horizon.

(A particular account of the variation, and of the several instruments used for determining it from observation, may be seen under the article Magnetism, where the method of communicating magnetism to compass-needles is also fully described.

Besides the variation, there is also the deviation of the compass arising from the local attraction of the iron on board ship, of which we have already given an account in the former part of this article. This deviation is always taken into account in ships of the Royal Navy, but not

Variation of the Compass.

always in ships belonging to the mercantile navy. In the latter case the variation is the whole difference between the observed bearing of the sun and the compass bearing; in the former, allowance must be made for deviation. We shall take deviation into account, as it is easy to omit it when it is not required.

To correct the variation for deviation, it will be sufficient to place under the variation, when determined by observation with its proper name, the deviation with a name *opposite* to its true name. Add these when the names are alike, and subtract the less from the greater if the names are different; and the remainder, with the name of the greater, is the true variation.

Prob. 1.—Given the latitude of a place, and the sun's declination, and the sun's magnetic amplitude, to find the deviation. [*Obs.*—The amplitude is the distance from the east point at which it rises, or from the west point at which it sets.]

Rule.—To the log. secant of latitude add log. sine of sun's declination; the sum, rejecting 10 from the index, will be the log. sine amplitude, which is east if the body is rising, and west if it be setting. The variation is the difference between the true and magnetic amplitudes if these be of the same name, and their sum if of different names. Also the variation is east if the true bearing is to the right of the compass bearing, west if the true bearing is to the left of the compass.

Ex.—May 18, 1857, about 5h 25m A.M., in Lat. 51° 5′ N., Long. 143° W., the sun rose by compass E. 6° 40′ S., the ship's head being E.; required the variation.

Ship, May 17				17h	25m 0s
Longitude				9	32 0 W.
				26	57 0
				24	0 0
Greenwich, May 18				2	57 0
Sun's declin., 18...	19°	36′	18″·0 N.		
„ 19...	19	49	36·1		
0·91039	0	12	58·1		
1·14244	0	0	0		
2·05283	0	1	36		
	19	37	44	Sin.	9·526303
Latitude...	51	5	0 N.	Sec.	0·201909
				Sin amplitude.	9·728212
True bearing				E.	32° 20′ 0″ N.
Compass				E.	6 40 0 S.
					39 0 0 W.
Deviation					8 50 0 W.
Variation					47 50 0 W.

It may be remarked, that the sun's amplitude ought to be observed at the instant the altitude of its lower limb is equal to the sum of fifteen minutes and the dip of the horizon. Thus, if an observer be elevated 18 feet above the level of the sea, the amplitude should be taken at the instant the altitude of the sun's lower limb is 19′ 11″.

Prob. 2.—Given the magnetic azimuth, the altitude and declination of the sun, together with the latitude of the place of observation, to find the variation of the compass.

Rule.—Find the polar distance by adding 90° to the declination if the altitude and declination have unlike names, and subtracting the declination from 90° if they have the same name.

Take the difference of the latitude and altitude, and obtain the sum and difference of this quantity and the polar distance.

To the log. secants of the altitude and declination add the halves of the log. haversines of the last two arcs; the result, rejecting 10 in the index, is the haversine of the true bearing, which take from the table. Or if a table not containing haversines is used, to the log. secants as before add the log. sines of half the arcs obtained as before; one-half of the result is the log. sine of half the true bearing. Double the arc taken out of the table is the true bearing.

The Tides

Mark the true bearing N. or S., according as the latitude is N. or S., and E. or W., according as the observed body is E. or W. of the meridian. The variation then can be found as before.

Ex.—On May 5, 1857, about 8h 10m 0s A.M., mean time, in Lat. 51° 10′ N., Long. 140° W., the sun bore by compass S. 65° 25′ E., and the observed altitude of the sun's lower limb at the same time was 28° 30′ 10″, the index correction was + 1′ 20″, and the height of the eye above the sea 15 feet, the ship's head being N.W.; required the variation of the compass.

Ship, May 4				20h 10m 0s
Longitude				9 20 0
Greenwich, May 5				5 30 0
Sun's semidiameter				0° 15′ 53″
Sun's declination, May 5				16° 19′ 13″·2 N.
„ „ 6				16 36 8
0·63985				0 16 55
1·02696				
1·66681				0 3 53
				16 23 6
				90 0 0
N.P.D.				73 36 54
Sun's altitude—				
Obs. altitude				28° 30′ 10″
Index correction				+ 0 1 20
				28 31 30
Dip				− 0 3 49
				28 27 41
Semidiameter				0 15 53
				28 43 34
Correction in altitude				− 0 1 38
True altitude				28 41 56
Latitude	51°	10′	0″	Sec. 9·802693
Altitude	28	41	56	Sec. 0·056924
Diff.	22	28	4	
Polar dist.	73	36	54	
Sum	96	4	58	Half havers. 4·871355
Diff.	51	8	50	Half havers. 4·625130
				9·760161
True bearing				N. 99° 37′ 22″ E.
Magnetic bearing				N. 114 35 0 E.
				14 57 38 L.
Deviation				4 50 0 E.
Variation				10 07 38 L.

Chap. VI.—OF THE TIDES.

The theory of the tides has already been explained under the article Astronomy, and will again be further illustrated under that of Tides. In this place, therefore, it remains only to explain the method of calculating the time of high water at a given place.

As the tides depend upon the joint actions of the sun and moon, and therefore upon the distance of these objects from the earth and from each other; and as, in the method generally employed to find the time of high-water, whether by the mean time of new moon, or by the epacts, or tables deduced therefrom, the moon is supposed to be the sole agent, and to have a uniform motion in the periphery of a circle whose centre is that of the earth; it is hence obvious that this method cannot be accurate, and by observation the error is sometimes found to exceed two hours. This method is therefore rejected, and another given, in which the error will seldom exceed a few minutes, unless the tides are greatly influenced by the winds.

TABLE I.—*For Determining the Time of High Water.*

Moon's Transit.	Moon's Horizontal Parallax. 60′	59′	58′	57′	56′	55′	54′	Moon's Transit.	Moon's Transit.	60′	59′	58′	57′	56′	55′	54′	Moon's Transit.
h. m.	m.	m.	m.	m.	m.	m.	m.	h. m.	h. m.	m.	m.	m.	m.	m.	m.	m.	h. m.
0 0	− 4	− 3	− 2	− 0	+ 2	+ 4	+ 6	12 0	6 0	− 56	− 58	− 60	− 62	− 65	− 69	− 72	18 0
10	6	5	4	3	− 1	+ 1	+ 2	10	10	52	54	56	59	62	65	68	10
20	8	7	6	5	4	− 3	− 1	20	20	49	51	53	55	58	60	63	20
30	10	10	9	8	7	6	5	30	30	46	48	50	51	54	56	58	30
40	12	12	11	10	10	9	8	40	40	43	44	45	47	49	51	53	40
50	15	14	14	13	12	12	11	50	50	38	39	40	41	43	44	45	50
1 0	17	17	16	16	16	15	15	13 0	7 0	32	33	33	34	35	36	37	19 0
10	20	20	19	19	19	19	18	10	10	27	27	28	28	29	29	30	10
20	22	22	22	22	22	22	22	20	20	22	22	22	22	22	22	22	20
30	24	24	25	25	25	25	25	30	30	18	18	17	16	16	15	14	30
40	27	27	28	28	28	29	29	40	40	11	11	10	10	8	7	6	40
50	29	30	31	31	31	32	33	50	50	6	6	5	4	2	0	+ 1	50
2 0	31	32	33	33	34	35	36	14 0	8 0	1	+ 1	+ 2	+ 3	+ 5	+ 7	+ 9	20 0
10	34	35	36	36	37	38	39	10	10	+ 2	4	5	7	9	12	14	10
20	36	37	38	39	40	42	43	20	20	5	7	9	11	14	16	19	20
30	38	39	40	41	42	44	46	30	30	8	10	12	15	18	21	24	30
40	40	41	43	44	46	48	50	40	40	11	13	16	18	21	25	28	40
50	42	43	45	46	48	50	52	50	50	13	16	18	20	23	27	30	50
3 0	44	45	47	49	51	53	55	15 0	9 0	14	17	19	21	24	28	32	21 0
10	46	47	49	51	54	56	58	10	10	15	18	20	23	26	30	34	10
20	48	49	51	53	56	58	61	20	20	17	19	22	25	28	32	36	20
30	50	52	54	56	58	61	64	30	30	16	18	21	24	27	31	35	30
40	52	54	56	58	61	64	67	40	40	16	18	21	24	27	31	35	40
50	53	55	57	60	63	66	69	50	50	16	18	21	23	27	30	34	50
4 0	55	57	59	62	65	69	72	16 0	10 0	15	17	20	23	27	30	34	22 0
10	56	58	61	63	66	70	73	10	10	14	17	20	22	25	29	32	10
20	57	60	63	65	68	72	75	20	20	13	16	18	20	23	27	31	20
30	58	61	64	66	69	73	76	30	30	12	15	17	19	22	26	30	30
40	59	62	65	67	70	74	78	40	40	11	13	16	18	21	25	28	40
50	60	62	65	67	70	75	79	50	50	9	11	14	16	19	22	25	50
5 0	60	63	66	68	71	75	79	17 0	11 0	7	9	12	14	17	20	23	23 0
10	60	63	66	68	72	76	80	10	10	6	8	10	12	15	17	20	10
20	60	63	66	68	71	75	80	20	20	4	6	7	9	11	14	17	20
30	59	62	65	67	70	74	78	30	30	2	4	6	7	9	12	14	30
40	58	61	63	65	68	72	76	40	40	0	2	4	5	7	9	11	40
50	57	60	62	65	68	71	74	50	50	− 2	− 1	1	2	4	6	8	50
6 0	− 56	− 58	− 60	− 62	− 65	− 69	− 72	18 0	12 0	− 1	− 1	+ 0	+ 0	+ 2	+ 4	+ 6	24 0

TABLE II.—*For finding the Height of the Tide.*

Time of Transit.		(PART I.) Moon's Hor. Par. 60′. Multipliers.	Moon's Hor. Par. 57′. Multipliers.	Moon's Hor. Par. 54′. Multipliers.	(PART II.) Time from H. W.	Mult.	Time from H. W.	Mult.
h. m.	h. m.				h. m.		h. m.	
0 0	12 0	0·995a+0·149b	0·883a+0·117b	0·795a+0·082b	0 0	1·000	3 10	0·510
0 40	12 40	1·104a+0·038b	0·970a+0·030b	0·874a+0·021b	0 10	0·998	3 20	0·460
1 20	13 20	1·138a+0·000b	1·000a+0·000b	0·901a+0·000b	0 20	0·993	3 30	0·429
2 0	14 0	1·104a+0·038b	0·970a+0·030b	0·874a+0·021b	0 30	0·985	3 40	0·389
2 40	14 40	0·995a+0·149b	0·883a+0·117b	0·795a+0·082b	0 40	0·974	3 50	0·349
3 20	15 20	0·853a+0·319b	0·750a+0·250b	0·676a+0·176b	0 50	0·959	4 0	0·311
4 0	16 0	0·668a+0·527b	0·587a+0·413b	0·529a+0·290b	1 0	0·941	4 10	0·274
4 40	16 40	0·460a+0·749b	0·413a+0·587b	0·372a+0·412b	1 10	0·921	4 20	0·238
5 20	17 20	0·284a+0·958b	0·250a+0·750b	0·225a+0·527b	1 20	0·897	4 30	0·204
6 0	18 0	0·133a+1·127b	0·117a+0·883b	0·105a+0·621b	1 30	0·871	4 40	0·173
6 40	18 40	0·034a+1·238b	0·030a+0·970b	0·027a+0·682b	1 40	0·843	4 50	0·143
7 20	19 20	0·000a+1·277b	0·000a+1·000b	0·000a+0·703b	1 50	0·812	5 0	0·116
8 0	20 0	0·034a+1·238b	0·030a+0·970b	0·027a+0·682b	2 0	0·779	5 10	0·091
8 40	20 40	0·133a+1·127b	0·117a+0·883b	0·105a+0·621b	2 10	0·774	5 20	0·069
9 20	21 20	0·284a+0·958b	0·250a+0·750b	0·225a+0·527b	2 20	0·708	5 30	0·050
10 0	22 0	0·460a+0·749b	0·413a+0·587b	0·372a+0·412b	2 30	0·670	5 40	0·033
10 40	22 40	0·668a+0·527b	0·587a+0·413b	0·529a+0·290b	2 40	0·631	5 50	0·020
11 20	23 20	0·853a+0·319b	0·750a+0·250b	0·676a+0·176b	2 50	0·591	6 0	0·010
12 0	24 0	0·995a+0·149b	0·883a+0·117b	0·795a+0·082b	3 0	0·551	6 20	0·000

The Tides.

TO FIND THE TIME OF HIGH-WATER.

Rule.—Let the approximate time of high-water be found, by taking the corrections for the moon's horizontal parallax for the nearest noon or midnight from Table I. Again, to this time and the given longitude take from the *Nautical Almanac* the moon's horizontal parallax. Also to the time of the moon's transit over the meridian of Greenwich apply the variation answering to the longitude and daily variation between the given and preceding day if the longitude is E. Subtract this from the transit over the meridian of Greenwich, and the remainder will be the time of transit over the meridian of the given place. But if the longitude be W., the correction answering to the longitude and daily variation of transit between the given and following day must be added to the time of transit over the meridian of Greenwich, to obtain the time of transit over the meridian of the given place. To the time of high-water, if new and full moon at the given place, add the reduced time of transit over the meridian of the same place, and to the sum apply the equation from the table answering to the time of transit and horizontal parallax formerly found; the result will be the true mean time of high-water required. The apparent time may be found by applying the equation of time, with its proper sign.

Ex. 1.—Required the time of high-water at Leith on Wednesday the 10th of May 1837, in Long. 3° 11′ W.

By the rule, the time of high-water will be about six o'clock in the evening. In this case, the moon's horizontal parallax will be 54′ 16″, and the time of transit $4^h\ 50^m$ mean time, or $4^h\ 54^m$ apparent time by applying the equation of time $3^m\ 50^s$ by addition.

Apparent time of transit of upper meridian...		$4^h\ 54^m$
Equation from the table to horizontal parallax 54′ 16″, and transit $4^h\ 54^m$, subtract.....	-1	18
Remainder	3	36
Time of high-water at new and full moon	$+2$	20
Apparent time of high-water.....	5	56
Equation of time.....	-0	4
Mean time of high-water.....	5	52

If the sum exceed $12^h\ 25^m$, subtract this number from it; if it exceed $24^h\ 50^m$, subtract as before, and the remainder will be the time of high-water in the afternoon of the given day nearly. The time of high-water of the tide preceding may be found nearly by subtracting 25^m from it, and the succeeding tide by adding 25^m to it. In cases of great accuracy, however, a computation should be made for each tide in a manner similar to that above.

Ex. 2.—Required the time of high-water at Aberdeen on the 21st of June 1837, in Long. 2° 6′ W.

As before, the time of high-water will readily be found to be about three o'clock.

Here the horizontal parallax of the moon will be 60′ 30″, and the mean time of transit on the given day $15^h\ 32^m$. But as this transit exceeds 12^h, it will be necessary to take the time of transit over the under meridian, or, what comes to the same thing, half the sum of the transits on the given and preceding days, or, $\frac{1}{2}(14^h\ 32^m + 15^h\ 32^m)$..... $= 15^h\ 2^m$

Correction from the table.....	$-$	0	44
Remainder.....		14	18
High-water at new and full moon	$+$	1	10
Sum exceeding 12^h.....		15	28
By rule, subtract		12	25
Apparent time of high water		3	3
Equation of time.....	$+$	0	1
Mean time.....		3	4

Ex. 3.—Required the depth at Aberdeen at the same time, the rise of spring tides being 19 feet, denoted by a in Table II., part 1, and that of the neap 14 feet, by b.

Now, by Table II., part 1, to transit $15^h\ 2^m$, and horizontal parallax 60′ 30″, will be obtained $0{\cdot}917 \times 19 + 0{\cdot}242 \times 14 = 20{\cdot}8$ feet.

Ex. 4.—Required the height of the tide at $3^h\ 15^m$ after high-water.

By part 2, $20{\cdot}8 \times 0{\cdot}5$..... $= 10{\cdot}4$ feet.

In this manner, the time and rise of the tide may be readily obtained nearly, unless both are much influenced by the strength and direction of the wind.

In the preceding pages we have not considered it our province to supply the reader with the tables which have been made use of in the solution of the several problems—*e.g.*, traverse tables, tables of meridional parts, corrections for dip, parallax, refraction, and log. haversines, log. rising, middle time, half-elapsed time, &c. For these, and for further information, we refer him to the works on Navigation already mentioned. Some of the rules we have given will be found to differ in some respects from those given in these works. These discrepancies, however, arise entirely from the slightly different form in which the formulæ on which the rules are based are made to appear, but not at all on any difference of principle. We have generally retained the forms of the formulæ which are best known to astronomical students. For example, we have retained Borda's method of clearing the distance, in lieu of the slight deviations from it which are frequently employed, not merely as being equally correct with the latter, but as possessing some historical interest. In clearing the distance by natural versed sines, it is not difficult to put the formulæ in such a form that the *sum* only of the versed sines may be taken. We have retained the formula in which two of the versed sines appear with a negative sign, as being that with which the readers of Hymer's Astronomy are already acquainted. Whenever the reader is familiar with astronomical formulæ, we recommend him to study the rules given in these pages with the appropriate formulæ before him; these he will find in any work on astronomy treated mathematically. In all cases, however, it is believed that, by a careful study of the rules and directions contained in this article, the reader will find himself possessed of all the information which will enable him to navigate a ship. (J. W—Y.)

NAVIGATION, INLAND.

Introduction.

Origin of navigation.

THE mariner's compass, it is believed, was first used at the commencement of the fourteenth century. Its introduction gave a new character to commercial enterprise, as it afforded the means of promoting to an almost unlimited degree the progress of maritime discovery. Since that early period the pursuit of Navigation has not only been the grand object to which the labours of Columbus and of all subsequent explorers of the world have been directed; but the researches of the philosopher, the astronomer, the geographer, the mechanician, and the engineer, have all been instrumental in bringing to maturity and perfection the various branches which constitute the system of Navigation as it now exists.

Its division into two departments.

What inland navigation is.

That system, though made up of many subsidiary parts, may conveniently and naturally be divided into two great departments. One of these is treated of in a separate article under the head of NAVIGATION; the other, which forms the subject of the present treatise, is termed Inland Navigation. It may shortly be defined as that branch of navigation which extends from the sea to the land, and affords the means of transport throughout the interior of a country. To form a correct estimate of the importance of this subject, it must be viewed in connection with the entire system of which it forms a part. For, how can we fully enjoy the benefits of those mighty results of science and of art, by which sailing vessels of all classes are now enabled to transport their cargoes from shore to shore, with comparative ease and safety, and gigantic steamers to traverse the ocean with certainty and despatch, if we do not, in addition to exhibiting the beacon light to welcome the approach of ships to our coasts, afford the means of withdrawing them from the ocean billows into sheltered havens, where their lading may be discharged, and cargoes of our country's produce may be shipped for foreign lands. It should be borne in mind, that it is only when the mariner approaches his destined port that the dangers caused by rocks, shoals, sand-banks, tides, and currents, beset his course; and the means of securing shelter for his vessel, and of opening up a passage into the interior of the country, may be held as embraced under the extensive subject of Inland Navigation.

Harbours.

The article HARBOURS fully discusses the construction of piers and breakwaters; and our present treatise will therefore be confined to Canal and River Navigation.

Topics to be discussed in present article.

Under these general heads we propose to give a brief account of canals, as applied to the purpose of transport by means of boats, and also on the larger scale, as affording to sea-borne vessels a sheltered and direct route to their destined ports. Our notice of rivers will embrace the navigation of their upper or landward streams, and also the varied means employed in opening up and rendering navigable their seaward or tidal compartments, which will necessarily lead us to consider the conservation of estuaries and the formation of bars. Viewed even in this restricted light, it will be found that inland navigation forms an extensive and intricate department of hydraulic engineering.

It is proper in the outset to state, that it is not our intention to explain the nature or principles of the varied class of works which the engineer finds it necessary to adopt in carrying out such operations as those to which we have alluded. At the present time, when so much is written on all branches of engineering, such a course would be uncalled for, and would indeed extend the present treatise greatly beyond the limits to which it must necessarily be restricted. For information as to such details, we must therefore direct the reader to the different books to which we shall have to refer, as containing full information on the subjects of which they treat. Our aim is rather to present the reader with a general *résumé* of the state of our knowledge respecting the practice of engineering, as applicable to inland navigation in all its branches, and to confine such detailed remarks as we may have to offer, to those parts of the subjects only, which are not fully treated in works already published; and here we must express our regret, that although we have many treatises expounding the principles of engineering, nevertheless the engineers of the present day have given comparatively few accounts of the effects that have followed the application of these principles in particular cases. In drawing up the following pages, the writer has found great difficulty in obtaining authentic information on *applied* engineering; and this must be his excuse for having in some of the sections been obliged to apply, it may be thought too largely, to his own experience for illustrations of his subject.

Canals.

SECT. I.—CANALS.

Canals.

It must be obvious to all, that railways, from which we have of late years derived such inestimable advantages, have now in a very great measure superseded, and certainly for the future must prevent, the general extension of canals. The great objections to relying on canals as the medium of regular and uninterrupted internal communication in this country, are the difficulty of obtaining a sufficient supply of water to prevent stoppages during dry seasons, the interruption to which they are exposed from ice during winter, and above all, in these days of express railway trains and electric telegraphs, the very limited speed at which the boats which navigate them can be propelled. Sir John Rennie, in speaking of the successful attempts made to introduce swift boats on canals, and the great improvement that was thereby effected in canal transport, says,—"All this, however, came too late; for although it would have been readily acknowledged at an earlier period, and might perhaps for a while have retarded the railway system, yet when once the latter was established, its superiority became manifest, and its progress irresistible."[1] These truly are considerations which make canals, when compared to railways as a means of transport and communication, appear so very disadvantageous, that it may at first sight be considered as uncalled-for to describe, even briefly, a class of works which, in the present day, may be regarded by some readers as almost entirely superseded. But although this remark may perhaps be justly considered applicable to those canals which effect a purely inland communication from town to town, it does not, in any degree, apply to that larger class of works called ship canals, which afford to sea-borne vessels an inland course, and enable them to avoid the dangers of a lengthened coasting voyage—an object of the highest importance to navigation, and one which it is obvious cannot be superseded by a railway. But, independently of this reservation on behalf of these peculiar works, it appears to us that the simple consideration of the great antiquity of navigable canals, their wide-spread introduction throughout the world, the important place which they have so long occupied in the commercial history of every country, and above all, the noble specimens which they afford of hydraulic engineering, should lead us naturally and imperatively to give some notice of their origin and subsequent progress; and this we shall do as briefly as possible, not so much from any feeling that the subject is superseded, or is unimportant, but because it will

[1] *Transactions of Inst. of Civil Engineers*, vol. v., p. 78.

Canals.

be found fully and ably treated in the works to which we shall have occasion to refer.

Their early history.

From the writings of Herodotus, Aristotle, Pliny, and other ancient historians, we learn that canals existed in Egypt before the Christian era; and there is reason to believe that, at the same early period, artificial inland navigation also existed in China. Almost nothing, however, save their existence, has been recorded with reference to these very early works; but soon after the commencement of the Christian era, canals were introduced, and gradually extended throughout Europe, particularly in Greece, Italy, Spain, Russia, Sweden, Holland, and France.[1]

In speaking, however, of the earliest of these works, it is not to be supposed that they resembled the modern canals as now constructed in our own and other countries. Early as inland navigation was introduced, it was not until the invention of canal-locks, by which boats could be transferred from one level to another, that the system was rendered generally applicable and useful; and it has been truly remarked, "that to us, living in an age of steam-engines and daguerreotypes, it might appear strange that an invention so simple in itself as the canal-lock, and founded on properties of fluids little recondite, should have escaped the acuteness of Egypt, Greece, and Rome."[2] Not only, however, had the invention escaped the notice of the ancients, but what is more striking, the several gradations made towards the attainment of that simple but valuable improvement appear to have been so gradual that, like many discoveries of importance, great doubts exist as to the *person* and even the *nation*, by whom canal-locks were first introduced. One class of writers attributes the discovery to the Dutch; and Messrs Telford and Nimmo, who are understood to have written the article on Inland Navigation in *Brewster's Edinburgh Enclyclopædia*, adopt the conclusion that locks were used in Holland nearly a century before their application in Italy: while, on the other hand, the invention has been strongly and not unreasonably claimed for engineers of the Italian school, and, in particular, for Leonardo da Vinci, the celebrated engineer and painter. Without, however, entering into a discussion of this question, which it is now probably impossible to solve, we may safely state, that during the fourteenth century the introduction of locks, whether of Dutch or Italian origin, gave a new character to inland navigation, and laid the basis of its rapid and successful extension. And here it may be proper to remark, that the early canals of China and Egypt, although destitute of locks, do not appear to have been on that account formed on a uniformly level line unadapted to varying heights. It is very doubtful, indeed, if the use of locks has even yet been introduced into China, intersected as it is by many canals of great antiquity and extent;[3] and in order to pass boats from one level to another, the Chinese have, from a very early period, employed stop-gates and inclined planes of rude construction. Nevertheless, the invention of locks was, as already noticed, a most important step in the history of canals; and that mode of surmounting elevations may be said to be almost universally adopted throughout Europe and America. Inclined planes and perpendicular lifts have, it is true, been employed in these countries, as will be noticed hereafter; but the instances of their application are undoubtedly rare.

Languedoc Canal.

But in proceeding to illustrate the progress of canals, we may, without tracing their gradual introduction from country to country, remark at once, that we find the French, at the end of the seventeenth century, in the reign of Louis XIV., forming the Languedoc Canal, designed by Riquet, between the Bay of Biscay and the Mediterranean, a gigantic work which was finished in 1681. It is 148 miles in length, and the summit level is 600 feet above the sea; while the works on its line embrace upwards of one hundred locks and about fifty aqueducts,—the whole forming an undertaking which is a lasting monument to the skill and enterprise of its projectors; and with this work as a model, it seems strange that Britain should not, till nearly a century after its execution, have been engaged in vigorously following so laudable an example. This seems the more extraordinary, as the Romans in early times had executed works in England, which, whatever might have been their original use, whether for the purposes of navigation or drainage, were ultimately, and that even at an early period, converted into navigable canals. Of these works, we particularly specify the Caer Dyke and Foss Dyke cuts in Lincolnshire, which are by general consent admitted to have been of Roman origin. The former extends from Peterborough to the River Witham, near the city of Lincoln, a distance of about 40 miles; and the latter extends from Lincoln to the River Trent, near Torksey, a distance of 11 miles. The Caer Dyke exists now only in name; but the Foss Dyke is at this moment an efficient and flourishing navigation; and having been lately professionally engaged in its improvement, the writer had occasion to inquire somewhat minutely into its history. Regarding this *oldest* British canal, Camden, in his *Britannia*, states that the Foss Dyke was a cut originally made by the Romans, and that it was deepened in the year 1121 by Henry I.; but to what extent it was deepened does not appear. In 1762 it was reported on by Smeaton and Grundy, who found the navigable depth at that time to be 2 feet 8 inches, and recommended several works for its improvement, which appear, however, not to have been executed. In 1782 Smeaton was again employed, and deepened the navigation to 3 feet 6 inches; but it does not appear that its width was increased;[4] and from that period it remained in a very imperfect state till 1840, when Messrs Stevenson of Edinburgh were employed to design works for assimilating the Foss Dyke, both as regarded the breadth and depth of the navigable channel, to the Rivers Witham and Trent, with which it communicated. Upon examination, the depth of the Foss was found to be 3 feet 10 inches, and its breadth in many places was insufficient for the passage of boats, for the convenience of which occasional passing places had been provided; and it was resolved to increase its dimensions, and otherwise repair the whole work. Accordingly, the canal was widened to the *minimum* breadth of 45 feet, and deepened to the extent of 6 feet throughout; alterations which were accomplished without stopping the traffic. The entrance-lock was renewed, and a pumping-engine was erected for supplying water from the River Trent during dry seasons; and that ancient canal, which is quoted by Telford and Nimmo "as the oldest artificial canal in Britain," is now in a state of perfect efficiency, forming an important connecting link between the Trent and Witham navigations.

Canals.

Ancient Roman canals in England.

Foss Dyke Canal.

Notwithstanding the existence of this early work, however, and of some others in the country, particularly the Sankey Brook navigation, opened in 1760, it is generally admitted that the formation of the Bridgewater Canal in Lancashire, the act for which was obtained in 1759, was the commencement of British canal navigation; and that Francis, Duke of Bridgewater, and Brindley the engineer, who were its projectors, were the first to give a practical impulse to a class of works which, under the guidance mainly of Smeaton, Watt, Jessop, Nimmo, Rennie, and Tel-

Bridgewater Canal.

[1] Fulton *On Canal Navigation*, London, 1796; Vallancey's *Treatise on Inland Navigation*, Dublin, 1763; Tatham's *Political Economy of Inland Navigation*, London, 1799; "Inland Navigation," Brewster's *Edinburgh Encyclopædia*.

[2] *Quarterly Review*, No. cxlvi., p. 281; *Treatise on Navigable Canals*, by Paul Frisi.

[3] The imperial canal of China is about 1000 miles in length.

[4] Smeaton's *Reports*, vol. i., p. 55, London, 1786.

Canals.

ford, has been very generally adopted throughout the country, and has undoubtedly been of vast importance in promoting its commercial prosperity.[1] It is believed that the canals which have been constructed in Britain exceed in the aggregate 4713 miles, and the system has been extensively carried out both in Europe and America.

Ship canals.

The introduction of canals adapted for the passage of boats was soon followed by a larger class of works, suited for the accommodation of sea-borne vessels. Thus the Forth and Clyde Canal, projected by Smeaton in 1766, and the Crinan Canal, executed by Rennie, are examples of navigations to enable sea-borne vessels of small size to pass from opposite coasts of the country, and escape long, and it may be hazardous, sea voyages. But these works are completely surpassed by others which have been formed on a scale of much greater magnitude, to admit vessels of heavy burden and large draught of water. Of these we may mention the Great North Holland Canal, designed and constructed by M. Blanken.[2] That canal, which extends from Amsterdam to the Helder, a distance of 51 miles, was finished in 1825. It is about 125 feet in breadth at the water surface, 31 feet at the bottom, and no less than 20 feet in depth of water; and what is most worthy of notice, and is indeed a characteristic of all Dutch engineering works, the greater part of it is protected from the German Ocean by embankments faced with wicker-work, the surface of the water in the canal being below the level of the sea at high water. At the time the writer inspected this work the sea was several feet higher than the surface of the water in the canal, and the vessels were actually being locked *down* from the ocean into the fertile plains of Holland. The object of this canal is to enable vessels trading from Amsterdam to avoid the islands and sandbanks of the dangerous Zuider Zee, the passage through which in former times often occupied as many weeks as the transit through the canal now occupies hours.[3]

North Holland Canal.

Caledonian Canal.

But our own country furnishes us with a similar work of great magnitude and boldness; we allude to the Caledonian Canal, originally projected by Watt and Jessop, and ultimately executed by Telford, which forms an inland navigation, composed partly of natural lakes, and partly of artificial canal, extending from Inverness to Fort-William, a distance of 60 miles. The artificial part of it is 120 feet in width at the top-water level, 50 feet at the bottom, and affords 20 feet of maximum depth. By means of this inland communication vessels are enabled to avoid the dangers of the Pentland Firth, and also in some measure the intricate navigation of the Western Islands; and while the Dutch in their great canal had to encounter the difficulties occasioned by the proverbial *lowness* of their country, Telford, in constructing the Caledonian Canal, had to deal with the ruggedness of a succession of Highland glens, and to surmount the summit-level of Loch Oich, which is about 80 feet above the level of the sea. Accordingly, in addition to many heavy works which occur in its course, there is at one point on the Caledonian Canal a succession of eight locks, by means of which a vessel of nearly the largest class of merchantmen can be raised or lowered through a height of 60 perpendicular feet. The locks, which are in close succession, rise one above another like a series of gigantic steps; and this unique and extensive marine ladder has not inappropriately been termed "Neptune's Staircase."[4]

Canals.

Difficulties in constructing canals.

It must be obvious that, in successfully carrying out works of such a nature, and on so gigantic a scale, no ordinary amount of engineering skill is requisite. Vast reservoirs must in some cases be formed for storing the water necessary to supply during dry seasons the loss by lockage, leakage, and evaporation. Feeders must be made to lead this water to the canal; hills must be pierced by tunnels; valleys must be crossed on lofty embankments, or spanned by spacious aqueducts; and above all, the whole must be conceived and laid out with scrupulous regard to the all-important object of securing the works against injury from an overflow of water during floods, and a consequent inundation of the surrounding country. Moreover, the necessity of laying out the canal in level stretches, and surmounting elevations by means of locks or inclined planes, occurring at intervals, often occasions much difficulty, and greatly restricts the resources of the engineer. Taking, then, all these circumstances into consideration, and bearing in mind that canals were the pioneers of railways, we think it may safely be affirmed that the canal engineers of former days had much more serious *physical* difficulties to contend with than are experienced in carrying out the railways in modern times; if we except such works as the Britannia Bridge, the high-level bridge of Newcastle, the Boxhill Tunnel, and some other kindred works. But, indeed, their *mechanical* difficulties were also greater; for the introduction of steam, and its wide-spread application to all engineering operations, affords facilities to the engineers of modern times which Smeaton at the Eddystone, Stevenson at the Bell Rock, and Rennie and Telford in their early navigation works, did not enjoy. We therefore gladly embrace this opportunity of acknowledging the distinguished merits of the engineers who practised at the end of the former and the commencement of the present century.

General principles of canal construction.

We have already said that we cannot in this treatise enter into details as to the construction of the various works adopted in executing canal navigations; and we shall here close our short historical notice of these works by submitting the following digest of the general principles which should guide the engineer in selecting the route and designing the construction of a line of canal:—

Supply of water.

1. The first object to which attention ought to be directed is the supply of water, on which the efficiency of a canal mainly depends. If there be no natural lake in the district available for storage, the engineer must select such situations as are suitable for the construction of artificial reservoirs. The conditions to be attended to in selecting the positions for these works are, that they command a sufficient area of drainage to supply the necessary amount of water; that their offlets are at such an elevation as to admit of water being conveyed to the summit-level of the canal; and that the embankments for retaining the water be erected on sites affording a favourable foundation, and so situated with reference to the valley above them that they shall, with the minimum height and breadth of embankment, dam up the maximum amount of water. It is further necessary to consider whether the subsoil of the valley forming the reservoirs is throughout of so retentive a nature as to prevent leakage; and it is also essential to provide, by means of waste weirs, for the discharge of floods. The Caledonian Canal is, in this respect, very favourably situated; no artificial reservoir having been required. Nearly the whole supply is

[1] *History of Inland Navigation, particularly those of the Duke of Bridgewater*, London, 1786 Hughes' "Memoir of Brindley," Weale's *Quarterly Papers*, London, 1843.

[2] *Transactions of Inst. of Civil Engineers*, vol. vi., p. 81.

[3] It was here that Bakker, a burgomaster of Amsterdam in 1688, introduced his "camel" for floating large vessels over the shoals of the Pampus, by means of which, according to Sir John Leslie, an Indiaman which drew 15 feet water had its draught reduced to 11 feet.

[4] The connection of the Atlantic and Pacific oceans by means of a navigable canal has long been under consideration, and the question has of late years assumed a more practical aspect. (For a review of the various schemes which have been proposed for carrying out this desirable object, the reader is referred to communications by Mr Joseph Glynn and Lieut.-Col. Lloyd, in the *Trans. of the Society of Civil Engineers*, vol. ix., p. 58, and vol. vi., p. 399.)

Canals. derived from Lochs Ness, Oich, and Lochy, which, indeed, constitute the greater part of the navigation; they afford ample depth of water, and though on different levels, they extend in an almost continuous line through the country. In other cases, such as the Union, Forth and Clyde, Crinan, Birmingham, and other canals, it has been found necessary to construct large artificial reservoirs, from which the water is led in feeders to points convenient for forming a junction with the canal. The water in these reservoirs, whether artificial or natural, is stored up in winter, and let off as required during the droughts of summer. In situations where the canal communicates with the sea or a tidal river, and where the natural supply is small, as in the case of the Foss Dyke, the water may be raised by pumping-engines.

Reaches and locks. 2. In determining the direction of a canal, it is of importance to consider the levels of the country through which it passes, and to lay out the work in a succession of level reaches, so as to overcome elevations *in cumulo* at those places where it can be most advantageously effected. This arrangement not only leads to a saving of attendance and expense in working the canal, but is also more convenient as presenting fewer stoppages to the traffic. The means of overcoming the difference of level between the various level reaches must depend very much on circumstances. With few exceptions, the change of level is effected by means of locks, which generally have a lift of from 8 to 10 feet, though in some cases it is somewhat greater. The dimensions of the locks ought to be regulated by the traffic; but they should, in order to save water, be as near as possible the size of the craft to be passed through them. The smallest class of canals have locks about 8 feet in breadth, and from 70 to 80 feet long; those on the Forth and Clyde are 20 feet in breadth, and 74 feet long; on the Caledonian Canal they are 40 feet broad, and 180 feet long, and on the great Holland ship-canal they are 51 feet broad, and 297 feet long. The water is gradually admitted into and flows from each lock by sluices formed in the gates. Sir William Cubitt, in carrying out the improvements of the Severn navigation, introduced the water through a culvert parallel to the side wall of the lock, and opening in the centre by means of a tunnel, which admits 16,000 cubic feet of water to flow into or out of the lock in 1½ minute; and in little more than that time loaded vessels can be passed through.[1] Inclined planes and perpendicular lifts, which have the great advantage of saving water, have also been adopted in a few cases. In 1837 the writer inspected the Morris Canal in the United States, constructed by Mr Douglas of New York, on the line of which there are no fewer than 23 inclined planes, having gradients of about 1 in 10, and an average lift of 58 feet each. The boats weighed, when loaded, 50 tons, and after being grounded on a carriage, were raised by water-power up the inclines with great ease and expedition. The length of the Morris Canal, which connects the Rivers Hudson and Delaware, and is a most interesting work, is 101 miles, and the whole rise and fall is 1557 feet, of which 223 are overcome by locks, and the remaining 1334 by inclined planes.[2] But inclined planes were used on the Ketling Canal in Shropshire in 1789, and afterwards on the Duke of Bridgewater's Canal. Mr Green introduced on the Great Western Canal a perpendicular lift of 46 feet; and more recently Mr Leslie, of Edinburgh, and Mr Bateman, constructed an inclined plane on the Monkland Canal, wrought by two high-pressure steam-engines of 25 horse-power each. The height from surface to surface is 96 feet, and the gradient is 1 in 10. The boats are not wholly grounded on the carriage, but are transported in a caisson of boiler-plate, containing 2 feet of water. The maximum weight raised is from 70 to 80 tons, and the whole transit is accomplished in about 10 minutes. For the five years previous to the end of 1836, the average number of boats that passed over the incline each year was 7500. Sir William Cubitt has also introduced three inclined planes, having gradients of 1 in 8, on the Chard Canal, Somersetshire. One of these inclines overcomes a rise of 86 feet, and they are said to act very satisfactorily.[3]

Canals.

Waste weirs. 3. An essential adjunct to a canal is a sufficient number of waste weirs to admit of the discharge of the surplus water which accumulates during floods, and which may, if not provided with an exit, rise to such a height as to overflow the tow-path, and cause a breach in the banks, producing stoppage of the traffic and damage to the adjoining lands. In determining the number and positions of these waste weirs, the engineer must be guided entirely by the nature of the country through which the canal passes. Whenever an opportunity occurs of discharging surplus water into a stream crossed by the canal, a waste weir may safely be introduced; but, independently of this natural facility, the engineer must consider from what quarters, and at what points, the greatest influx of water may be apprehended, and must at such places not only form waste weirs of sufficient size to void the surplus, but prepare artificial courses for their discharge into the nearest streams. These waste weirs are overflows placed at the top water-level of the canal, so that in the event of a flood occurring, the water flows over them, and thus relieves the banks. The want of sufficient escape for flood-water has occasioned overflows of canal banks which were attended with very serious injury to the works, and lengthened suspension of the traffic; and attention to this particular part of canal construction is of essential importance.

Stop-gates. 4. Another very necessary precaution is the introduction of stop-gates at short intervals of a few miles, for the purpose of dividing the canal into isolated reaches, so that in the event of a breach occurring, the stop-gates may be shut, and the discharge of water confined to the small reach intercepted between them, instead of extending throughout the whole line of canal. In large works these stop-gates may be most advantageously formed in the same manner as the upper gates of locks, two pairs of gates being made to shut in opposite directions. In small works they may be made of thick planks, which are slipped into grooves formed at those narrow parts of the canal which occur under road bridges, or at contractions made with grooves at intermediate points to receive them. Self-acting stop-gates have been tried, but their success has not been such as to lead to their general introduction. Stop-gates are further found to be very useful in cases of repairs, as they admit of the water being run off from a short reach, when the repairs can be made, and the water restored, with comparatively little interruption to the traffic. Their value in obviating serious accidents was well exemplified on one occasion in the experience of the writer, when the water during a heavy flood flowed over the towing-path at the end of an aqueduct adjoining a high embankment, and the uncontrolled current carried away the embankment, and the soil on which it rested, to the depth of 80 feet, as measured from the top water-level. The stop-gates were, on the occasion referred to, promptly applied, and the discharge confined to a short reach of a few miles, otherwise the injury (which was, even in its modified form, very considerable) would have been enormous.

Offsets. 5. For the purpose of draining off the water to admit of repairs after the stop-gates have been closed, it is necessary to introduce, at convenient situations, a series of

[1] *Transactions of Institution of Civil Engineers.*
[2] Stevenson's *Sketch of Civil Engineering in North America.*
[3] *Transactions of Institution of Civil Engineers*, vol. xiii., p. 205.

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exits called offlets, consisting of pipes placed at the level of the bottom of the canal, and fitted with sluices which can be opened and shut when required. These offlets are generally formed at aqueducts or bridges crossing rivers where the contents of the canal can be run off directly into the bed of the stream, the stop-gates on either side being closed so as to isolate the part of the canal from which the water is withdrawn.

Drainage of tow-paths.

(6.) In executing the work, provision must be made for the proper drainage of the tow-paths, especially in cuttings. The drainage of the tow-paths should be carried to a sky drain at the bottom of the cutting, and at intervals passed below the tow-path into the canal. The preservation of the banks at the water-line is also a matter of importance. "Pitching" with stones and "facing" with brushwood are employed, and, in the writer's experience, the latter, if well executed, forms an economical and effectual protection.

(7.) In forming the *alveus* or bed of the canal, care must be taken, particularly on embankments, and also in cuttings, if the soil is porous, to provide against leakage by

Puddling.

the application of puddle. And here it is proper to remark, that an all-important matter, as affecting the construction of the works, is the possibility of getting clay in the district, or such other soil as may be worked into puddle, on the good quality of which the stability of the reservoir embankments, and the imperviousness of the beds and banks of the canal, mainly depend.

These are the only points of general application in the construction of canals to which we can advantageously direct attention in the present communication. In carrying them into practice, the engineer must be guided partly by the valuable details to be found in the works to which reference is made in this article, but mainly by that experience which can be gained only by the study of works in actual operation.

We do not propose to extend our remarks to the means of conducting traffic on canals and rivers, and have to refer the reader for information on that subject to observations and works on Traction and Steam Navigation. On the former subject the reader may consult the observations, by Mr Walker and Mr George Rennie, in the *Transactions of the Royal Society* and of the *Institution of Civil Engineers;* and especially the very valuable researches on Hydrodynamics, by Mr Scott Russell, in the *Edinburgh Philosophical Transactions.* On the latter he is referred to the articles STEAM-ENGINE, and STEAM NAVIGATION.[1]

SECT. II.—RIVERS, THEIR PHYSICAL CHARACTERISTICS.

Difference between canal and river navigation.

From what has been said, it will be seen that a canal may be described as a work by which water is diverted from its natural course, and made to occupy a channel prepared for its reception, extending through the country for the transport of boats and vessels. Canal navigation is thus entirely *artificial* in its character. In this respect it differs from river navigation, which may be described as the art of using, for the purposes of inland communication, rivers flowing in their natural courses, and of applying means to render them subservient to the purposes of navigation in cases where the depth is limited, or where rapid currents exist. Our consideration of rivers must therefore necessarily comprehend a general sketch of their physical characteristics, and the laws of their motion, as a necessary introduction to the more practical part of the subject, embracing the engineering works required for their improvement, with which we have chiefly to deal in this treatise.

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The compartments described as occurring in rivers.

As introductory, therefore, to the remarks which are to follow, it seems desirable to premise, as described by the writer in a communication to the Royal Society of Edinburgh,[2] that in all rivers affected by tidal influence, two physical boundaries, more or less apparent, are invariably found to exist, caused by the influx of the tidal wave through firths or bays, and the modification it receives in its passage up the gradually rising inclination or slope of a river's bed. These boundaries again produce three compartments. The seaward, or lowest of these, the writer termed the "sea proper;" the next, or intermediate one, into which the sea ascends, and from which it again withdraws itself, was termed the "tidal compartment of the river;" and the highest, or that which is above the influence of the sea, the "river proper." Their relative extent in different situations is influenced not only by the circumstances under which the great tidal wave of the ocean enters the river, but by the size of its stream, the configuration and the slope of its bed, and, in short, by every natural or artificial obstruction which is presented to the free flow of the tidal currents along its channel.

Their physical characteristics.

These three compartments possess very different physical characteristics. The presence of *unimpaired tidal phenomena* in the lowest, the *modified flow of the tide*, produced by the inclination of the river's bed in the intermediate, and the *absence of all tidal influence* in the highest compartment, may be shortly stated as the phenomena by which these spaces are to be recognised. The tides in the "sea proper" compartment of an estuary, for example (although the place of observation be several miles embayed from what in strictness could be called the "sea" or "ocean"), will be found to resemble those of the adjoining sea with which it communicates,—1*st*, in the identity of the levels of low water; 2*d*, in the shortness of the time which elapses between the cessation of ebbing and the commencement of flowing, or, in other words, the absence of any protracted period of low water, during which the surface appears to remain stationary at the same level; 3*d*, in the symmetrical form traced by the passage of the tidal wave; and 4*th*, in the range of tide, so far as that is not influenced by the formation of the shores in narrow seas or channels. In ascending into the intermediate compartment, however, the level of the low water is no longer the same; the range of tide, excepting in peculiar cases, becomes less, and is gradually decreased as the bed of the river rises, and at length a point is reached where its influence is not perceptible. In this intermediate section the phenomena of *ebbing* and *flowing* are still found to take place, but the times of ebb and flow do not remain constant, that of ebb gradually gaining the ascendency; the duration of low water being gradually protracted as we proceed upwards, until the influence of tide is unknown. This forms the boundary line of the upper compartment, the characteristic of which is the total absence of ebbing and flowing; the river at all times pursuing its downward course in an uninterrupted stream, and at an unvarying level, except in so far as may result from the changes due to land floods.

In the investigation of these different characteristics, the variable nature of the elements to be dealt with must be kept in view. The river, for example, is liable to be affected by floods, and the state of the tides by winds and other causes; and therefore a great degree of precision in defining these spaces cannot in all cases be expected, nor indeed is it necessary for the purpose of the present inquiry. But it is satisfactory to know that the termination of the low-water level at the separation of the seaward and intermediate spaces, as laid down by marine surveyors, simply from ob-

[1] Researches on Hydrodynamics, from *Transactions of Royal Society of Edinburgh*, 1837, by J. S. Russell; "On the Resistance of Fluids to Bodies passing through them" (*Philosophical Transactions*, 1828), by James Walker, C.E.

[2] *Proceedings of the Royal Society of Edinburgh*, vol. ii., p. 26.

servation of the tidal phenomena, has in several situations been found to agree exactly with the position of that boundary as determined by engineers by means of accurate levelling, combined with careful tidal observations.

Tidal phenomena of Dornoch Firth.

But an example in actual practice will best illustrate what is meant, and for this purpose we shall refer to the investigation of the tidal phenomena, made by the writer in 1842, of the Firth of Dornoch and Kyles of Sutherland in Cromartyshire. By referring to the small chart of the Dornoch Firth in Plate I., the reader will be better able to follow the illustrations to be given. The harbour of Portmahomac, marked A on the chart, about 3 miles from Tarbetness Lighthouse, was selected as the place at which to observe the *ocean* or *sea wave*. The second station at which it was found convenient to institute observations was within the Firth at Meikleferry, marked B, about 3 miles above the town of Tain, and 11 miles distant from Portmahomac. The third station was at Bonar Quarry, marked C, situated on the north shore of the Firth, and 8 miles inland from Meikleferry; and the fourth station was at Bonar Bridge, marked D, one mile from the Bonar Quarry. Beyond Bonar Bridge the observations were also extended as far as the junction of the Rivers Oykell and Cassley, marked E, a distance of 12½ miles; so that the whole distance embraced in the investigation was 33½ miles. Graduated tide-gauges were fixed at Portmahomac, Meikleferry, Bonar Quarry, and Bonar Bridge; and by means of two distinct sets of observations, the levels of these gauges, in relation to each other, were accurately determined, so that all the tidal observations made at them could be reduced to the same *datum* line. The result of the observations was, that *the low-water of each tide is, practically speaking, on the same level at Portmahomac, Meikleferry, and Bonar Quarry*. We use the word *practically*, because the level of the sea is more or less affected by every breeze of wind, which necessarily must *pen up* and elevate some portions of its surface, and cause corresponding depression, at other places, so that an unvarying low-water line will not be found to exist throughout a series of tides on any part even of the ocean itself, however limited the number of low-waters embraced may be. Accordingly, deviations from a truly level line of a few inches occasionally occurred in the observations made at the Dornoch Firth; but these were not of greater extent than could reasonably be traced to the effect of wind, and were found to vary, not only in their amount, but also in their value, being sometimes *plus* and sometimes *minus* quantities, causing corresponding variations in the results deduced from the different series of tidal observations that were made. Some of these showed the low-water within a fraction of an inch of being level; while others gave a notable *elevation* at some of the stations; and others, again, gave a *depression* below the level line at the very stations where previously there had been a rise.

Low water line practically level from Portmahomac to Bonar Quarry.

To illustrate this more fully, we shall give a few examples: Thus, on the 23d of June (on which day the weather happened to be very calm), the level of low-water at Meikleferry was three-quarters of an inch *above* that at Portmahomac; and on the next day, the wind blowing fresh from the S.E., the level of low-water at Meikleferry was 3¾ inches *above* that at Portmahomac. Again, a succeeding observation gave the level of Meikleferry three-quarters of an inch *below* Portmahomac. In the same way, and in similar small degrees, the level between the low-water at Bonar Quarry tide-gauge and at Portmahomac was found to vary. The *average* of all the observations made, gave the level of low-water at Meikleferry 2·2 inches *above* that at Portmahomac, and the level of low-water at Bonar Quarry 1·1 inch *below* the low-water at Portmahomac. Whether these *average* differences of level be traceable to the effects of prevailing winds, which may be supposed to have exerted a greater influence on the water at the more exposed stations, or to any inaccuracy in the levels, must evidently, from the examples given of the extent and nature of the daily deviations, be a point which we cannot determine; but the result of a lengthened train of observations, notwithstanding the *average* difference above stated, may fairly be held to be, that the low-water of each tide is *practically* on the same level at Portmahomac, Meikleferry, and Bonar Quarry; and therefore that the *low-water* tidal phenomena, throughout the whole extent of the firth, correspond with those of the sea.

Low-water rises from Quarry to Bonar Bridge.

But when the results of the observations at Bonar Bridge come to be compared with those made at the seaward station, a very marked difference presents itself; for, while the low-water line is found to be practically level from Portmahomac to Bonar Quarry, a distance of 20 miles, throughout a narrow firth, varying from 1¼ mile to 550 feet in breadth at low-water, we find that between the Quarry and Bonar Bridge, a distance of only one mile, there is a rise in the low-water line of spring-tides of no less than 6 feet 6 inches. It was therefore concluded that, in the Dornoch Firth, the point at which the low-water level of spring-tides met the descending current of fresh water, lay somewhere between the Quarry and Bonar Bridge. A different series of observations was made to ascertain the exact point at which this junction takes place, and the result of these observations was, that at low-water of an ordinary spring-tide, rising 14 feet at Meikleferry, the low-water level of the sea meets or intersects the descending fresh-water stream from the Kyle of Sutherland, at a point 1700 yards below Bonar Bridge, or nearly opposite Kincardine Church, and within 60 yards of the Quarry station. Between this point and the bridge, a distance of 1700 yards, there is a rise of 6 feet 6 inches, giving an average slope on the bed of the river of 1 in 784, or 6·7 feet per mile.

In addition to this uniformity in the level of low-water, it was further found that the tidal phenomena of the firth corresponded to that of the adjoining sea, in the outline traced by the passage of the tidal wave, as deduced from observations made at the different stations on the rise and fall of the tide level between the periods of low and high water. During the period between each low-water or high-water the level of the surface was ever varying, there being no lengthened cessation of ebbing and flowing, the tide-wave being fully developed at the whole of the stations up to Bonar Quarry. The range of tide was indeed increased in the inner part of the firth to the extent of 9 inches at Meikleferry, and 12 inches at Bonar Quarry; that is, when the rise of tide was 12 feet 8 inches at Portmahomac, it was 13 feet 5 inches at Meikleferry, and 13 feet 8 inches at Bonar Quarry—an increase which is due to the momentum of the tidal wave when obstructed by the contracting shores of the firth, and is accounted for by the principle of the conservation of forces.[1]

Rise of tide at Bonar Bridge.

But if we inquire into the tides at Bonar Bridge, we find that they do not correspond with those of the adjoining [illegible] the firth; for taking the tide to which we have already [illegible], which rose 13 feet 8 inches at Bonar Quarry, it was found the same day to rise only one-half of that amount, or 6 feet 10 inches at Bonar Bridge; the difference between the two results being occasioned by the rise on the low-water line of the channel between these two places. The tide on the particular day alluded to rose no less than 6 feet 10 inches at Bonar Quarry before it attained the level of the low-water at Bonar Bridge, when it began to rise at that place also, and afterwards continued to flow nearly uniformly at

[1] Essay towards a First Approximation to a Map of Co-tidal Lines, by the Rev. W. Whewell, *Philosophical Transactions*, 1833.

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both places. Fig. 1 is a diagram illustrative of the form of the tide-wave at Meikleferry and Bonar Bridge, the hard line represents the curve formed by the passage of the tidal wave at Meikleferry, and the dotted line shows that at Bonar

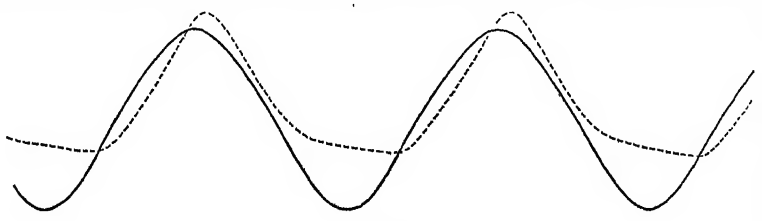

Fig. 1.

Bridge. In both cases the vertical space represents the rise of tide, and the horizontal space the elapsed time. From this diagram it will be seen, that while the tide at Meikleferry is symmetrical, and presents a constantly rising or falling outline, the tide at Bonar Bridge represents a long period, extending on some occasions by actual observation to several hours at low-water, nearly unaffected by tidal influence, during which period the water stood almost at the same level. The tidal water admitted into the upper part of the estuary above Bonar Bridge took a considerable time to drain off through the narrow water-way at that place, and hence the water did not attain a permanent low-water level, even long after the tide had ceased to operate in affecting its surface. The observations made to ascertain how far the tidal influence extended up the Kyles of Sutherland were conducted with the same care, and proved that the highest point influenced by the tide was at the junction of the Rivers Oykell and Cassley, 12½ miles above Bonar Bridge.

Mean sea-level.

A further test of the "sea proper" will, it is believed, be found in the existence, at any place of observation within that compartment, of a central point in the vertical range of tide from which the high and low water levels of every tide are very nearly equidistant. The existence of such a point was, it is believed, first determined by Mr James Jardine at the Tay in 1810,[1] and has been observed in the firths of Forth and Dornoch, at the Skerryvore Rocks on the west of Scotland, at the Isle of Man, and in the Mersey. These different series of observations, made at points so far distant from each other, seem to prove the universality of the phenomenon, at least on the shores of this country. But in ascending into the tidal compartment, the rise on the low-water level, which has already been described, destroys at once the symmetry of the tide-wave, as shown in fig. 1, and the existence of any such central point equidistant from the high and low water level of each tide.

The case we have adduced will serve to illustrate the definition we have given of the compartments of rivers. From Portmahomac to Kincardine, near Bonar Quarry, we have all the evidences of what we have termed the "sea proper;" the line traced through the low-water mark at different parts of the firth is practically level; the curve formed by the rise and fall of the tide is symmetrical; there is no lengthened cessation of ebbing and flowing at the period of low water; and the range of tide is unmodified save by the additional rise due to the narrow frith through which the tide-wave passes. From Kincardine to the junction of the Oykell and Cassley, we have proofs no less evident of the modified flow of the tide peculiar to the "tidal compartment." Even at Bonar Bridge, one mile above the quarry, the low-water level is 6 feet 6 inches higher than at the station below. At low-water the tide remains within a few inches of the same level for several hours, and its maximum range is reduced to about one-half of what it is further seaward, while at the junction of the Oykell and Cassley it disappears altogether. Above this point no tide is known to affect the flow of the stream, which, being free from all tidal influence, may be termed the "river proper."

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These boundaries not equally distinct in all cases.

We must here warn the reader not to suppose that the boundaries we have traced as existing in the Dornoch Firth, and many other places which the writer has investigated, may be determined with the same precision under all circumstances and in every case. The observations to which we have alluded, are supposed to be made at periods when the river is free from floods and the sea unaffected by heavy gales; moreover, the configuration of the bottom and shores of a river and estuary may, in certain cases, render the accurate determination of the boundaries very difficult. All that we assert is, that these compartments do in some measure, more or less defined, exist in all cases; and although not determined with the same careful precision as explained in the case of the Dornoch Firth, we have made observations of a more general character, and with complete success, to define approximately the tidal compartments in many estuaries and rivers in Britain and Ireland.

Data required by the engineer.

But there are other data with which the engineer must be furnished before he can advantageously consider the improvement of any part of a river. These data include the determination of its slope, velocity, and discharge, the nature of its bed and banks, and many other particulars. For full details as to the character and extent of such information, and the means of obtaining it, we can only refer the reader to works on the subject of River and Marine Surveying.[2] Neither do we include in the present treatise any sketch or digest, however brief, of the interesting and gradual progress made by philosophers and engineers of the early Italian and French schools, in the theoretical and experimental investigations of the laws which regulate the flow of water in natural and artificial channels, which investigations form the basis of all our practice in hydraulic engineering. These lengthened and laborious experimental researches will be found to be most fully discussed—historically, theoretically, and practically—in the valuable article by Dr Robison on the Theory of Rivers, in this Encyclopædia (see RIVER), and also in the report made by Mr George Rennie to the British Association on the progress and present state of our knowledge of hydraulics as a branch of engineering.[3]

While we do not therefore propose to advert at length either to the theoretical or practical details of the subject, still the whole of river engineering is so connected with, and dependent on, those physical characteristics of rivers which are termed the *slope*, the *hydraulic mean depth*, the *velocity*, and the *discharge*, that it seems to be indispensable to a proper understanding of the subject that these elements should be defined, and that the relations which subsist between them should be considered. The following definitions will suffice to answer the purpose in view :—

Definitions.

1. The *slope* is the fall on the surface of the river, which is generally expressed in feet or inches per mile.

2. The *hydraulic mean depth* is the quotient arising from dividing the sectional area of the channel in square feet by the wetted border or perimeter in lineal feet.

3. The *mean velocity* is that velocity which is common to the whole cross section of a stream, and is represented by the discharge divided by the area of that section.

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[1] *Report* by James Jardine, C.E.

[2] *Treatise on the Application of Marine Surveying and Hydrometry to the Practice of Civil Engineering*, by David Stevenson, C.E. Edinburgh, 1842.

[3] *Report of the British Association for the Advancement of Science* for 1834.

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4. The *discharge* is the quantity of water yielded by the stream in a given time, and is generally stated in cubic feet.

Method of ascertaining discharge by measurement;

In the practice of engineering it is frequently necessary to consider questions involving the relations which subsist between these different elements, and many formulæ have been proposed to facilitate this operation. The Chevalier Dubuat was the first investigator who, by discovering the effects of the friction of fluids on their own particles, and on the bed along which they move, was enabled to apply his theoretical knowledge of hydraulics to practical purposes, and his views and formulæ will be found fully discussed in the article RIVER already alluded to. The writer of this article has, however, found that such formulæ are not *generally* applicable, and it seems desirable to lay before the practical engineer the various results given by different formulæ when applied under the same circumstances, in order that he may be cautioned as to relying on such a means of computation in cases where great exactness is requisite. In order to ascertain the discharge of a stream or river, the writer has therefore in practice resorted to actual measurement. For this purpose, a situation was selected where the bed was tolerably uniform in its longitudinal and transverse outline. A correct transverse section of the bed or channel was made, and the section was divided into compartments. The surface velocity in the centre of each compartment was then taken by means of floats, or the instrument called the *tachometer*. These surface velocities were reduced to mean velocities for each compartment by Dubuat's formula:—

$$M=\frac{(\sqrt{V}-1)^2+V}{2}$$

or more simply, in cases where great accuracy is not required,

$$M=0{\cdot}8\ V$$

where V = the observed surface velocity in inches per second.
M = the mean velocity in inches per second.

We have found by means of the tachometer, used at different depths, that this formula expresses accurately the mean velocity of *any vertical section* of the stream to which the observed surface velocity is applicable. But as the surface velocity on the same cross section is not uniform throughout the width of the stream, it becomes necessary, as already stated, to divide the section into compartments, so as to embrace the maximum and minimum speeds. The areas of the different sections being then multiplied by the corresponding mean velocities obtained by either of the above formulæ, the sum of the discharge due to the different compartments is held to give the total discharge of the stream or river. It is obvious that the accuracy of the result obtained by this process depends on the judgment with which the cross-sectional area is subdivided, and on the care with which the observations are made. The operation is, in many cases, attended with difficulties, and in all with a considerable consumption of time; and many formulæ have been proposed to shorten it. The writer has compared the computed discharge given by several of these formulæ with the discharge as ascertained by careful observations made in the manner described, and the following result is submitted for the information of engineers.

and by formulæ.

The formulæ subjected to trial were:—

I. Formula given by Dr Robison, founded on Dubuat's investigations:[1]

$$M=\frac{307\ (\sqrt{d}-0{\cdot}1)}{\sqrt{S}-\text{Hyp. log. of }\sqrt{S}+1{\cdot}6}-0{\cdot}3\quad(\sqrt{d}-0{\cdot}1)$$

in which M = the mean velocity in inches per second,
d = the hydraulic mean depth in inches,
S = the reciprocal of the slope of the surface which is the denominator of the fraction expressing the slope, the numerator being always unity (a slope of 1 foot a mile is $\frac{1}{5280}$, therefore 5280 = reciprocal for that slope),
Hyp. log. = the common log. of the number to which it is attached, multiplied by 2·3026.

II. Formula given by Sir John Leslie:[2]

$$M=\frac{15}{16}\sqrt{af}$$

in which M = the mean velocity in miles per hour,
a = the hydraulic mean depth in feet,
f = the fall on the surface in feet per mile.

III. Formula given by Mr Ellet for calculating discharge of the Mississippi:[3]

$$V=\frac{8}{10}\sqrt{df}+\frac{df}{20}$$

$$M=0{\cdot}8\ V$$

in which V = the surface velocity in feet per second,
d = the maximum depth of the river in feet,
f = the fall on the surface in feet per mile,
M = the mean velocity in feet per second.

IV. Formula given in Mr Beardmore's tables:[4]

$$M=\sqrt{a}\,2f\times 55$$

in which M = mean velocity in feet per mile,
a = hydraulic mean depth in feet,
f = fall per mile in feet.

V. In addition to these formulæ, the writer also subjected to trial the formula:

$$M=\frac{(\sqrt{V}-1)^2+V}{2}$$

in which M = the mean velocity in inches per second,
V = the maximum surface velocity in the axis of the stream in inches per second.

In order to compare these different formulæ, a very favourable situation was selected for ascertaining the discharge of a stream by careful measurements of its sectional area and of the velocities at different parts of its surface from the centre to either side, and the result gave a discharge of 1653 cubic feet per minute, which, from various measurements, the writer believes to be a very near approximation to the actual discharge. The slope was also accurately ascertained, and the following are the results:—

	Cubic feet.	
Discharge from measurement as above,	1653	per minute.
1st. By Robison's formula.....	2214	do.
2d. By Leslie's do.	2474	do.
3d. By Ellet's do.	2784	do.
4th. By Beardmore's do.	2333	do.
5th. By formula assuming the mean deduced from the centre surface velocity as the mean for the whole section ...	1950	do.

It will be seen from this statement, that none of the formulæ afford a near approximation to the discharge of the small stream to which they were applied.

Again, it was ascertained by the late Dr Anderson, after most carefully dividing the cross section into compartments, that the discharge of the main branch of the Tay at Perth was 147,391 cubic feet per minute.[5] The writer has also ascertained the discharges, as calculated by the different formulæ as above, and the following are the results:—

[1] See article RIVER; also *A System of Mechanical Philosophy*, by John Robison, vol. ii., p. 453.
[2] *Elements of Natural Philosophy*, by Professor Leslie, Edinburgh, 1829, vol. i., p. 423.
[3] *The Mississippi and Ohio Rivers*, by Charles Ellet, Philadelphia, 1853.
[4] *Hydraulic Tables*, by Nathaniel Beardmore, C.E., London, 1852.
[5] This does not include the Willowgate, nor the Earn.

Rivers.

	Cubic feet.	
Discharge per measurement	147,391	per minute.
1st by Robison's formula	153,632	do.
2d „ Leslie's	166,134	do.
3d „ Ellet's	122,002	do.
4th „ Formula in Beardmore's tables	156,569	do.
5th „ Formula assuming the mean deduced from the centre surface velocity as the mean for the whole section	179,237	do.

Formula generally applicable, but affording only an approximation.

The result of these trials, and others which the writer has had occasion to make, is, that none of the formulæ that have been proposed will be found *generally* applicable. As it is often convenient, however, to be able to approximate to the velocity or discharge due to a given area and fall, the following formula may be applied, and will, in most cases, give a pretty near approximative result, viz.:—

$$x = y\sqrt{af}$$
$$z = \frac{x \times 5280}{60}$$
$$D = sz$$

in which x = the mean velocity of the whole section of the stream in miles per hour,
y = a quotient which is found to vary from 0·65 for small streams under 2000 cubic feet per minute, to 0·9 for large rivers, such as the Clyde or the Tay,
a = the hydraulic mean depth in feet,
f = the fall on the surface in feet per mile,
z = the mean velocity of the whole section of the stream in feet per minute,
s = the sectional area of the stream in feet; and
D = the discharge in cubic feet per minute.

It must still be kept in view that the application of any known formula to the determination of the mean velocity and discharge of a river is shown, by experimental inquiry, to afford only a rough approximation; and that if a near approximation is required, it must be obtained by means of observations embracing the velocities at different parts of the cross-sectional area, made in the manner already described.

Result of formula destroyed where under-currents exist.

We must offer the further caution, that those rules whereby the mean velocity is deduced from, or is assumed as bearing any constant ratio to, the surface velocity, do not apply in many situations which are within the influence of the tide. As will be explained more fully hereafter, the fresh water of the river being specifically lighter, is to a certain extent borne up by and floats upon the denser water of the sea. In surveying the Dee at Aberdeen in 1810, Mr Robert Stevenson found that, while there was an *outward* upper-current of fresh water, there was an *inward* under-current of salt water; so that, although the upper stratum was constantly running toward the sea, there was a regular rise and fall of the surface produced by the influx of the tidal waters below. Another instance of such an under-current, though not occasioned by the presence of a river, was found to exist in a marked degree at the Cromarty Firth by Mr Alan Stevenson in 1837. The waters of the Cromarty Firth pass to and from the sea through the narrow gorge between the Suters of Cromarty, where the width is about 4500 feet, and the depth about 150 feet. The mean velocity due to the column of water passing this gorge, as deduced from the observed surface velocity, was not sufficient to account for the quantity of water actually passed during each tide, as determined by measuring the cubical capacity of the basin of the firth. This led to the observation of the under-currents through the gorge by means of submerged floats, and it was found that during flood-tides the surface velocity was 1·8 mile per hour; while at the depth of 50 feet the velocity was not less than 4 miles per hour, being an increase of 2·2 miles per hour. During ebb-tide the surface velocity was 2·7 miles per hour, and at 50 feet it was not less than 4·5 miles per hour, being an increase of 1·8 mile per hour. The existence of these under-currents is due to some obscure causes connected no doubt with the configuration of the bottom, and the circumstances under which the tidal wave approaches and recedes from the shore. The existence of a powerful oceanic under-current during the flood-tide may account for the increased under-velocity of the tide flowing into the Cromarty Firth; and if we suppose a similar rapid under-current to sweep along the coast during the ebb-tide, the tendency would be to draw off the water more quickly from the lower part of the channel between the Suters which forms the mouth of the firth, and thus to increase the velocity at and near the bottom during the ebb-tide, as also indicated by the observations to which we have alluded. It is evident that in all such situations the application of a *common* or *mean* velocity, deduced from the observed surface velocity, cannot be relied on as correct.

Rivers.

As the slopes, velocities, and discharges of rivers are so important in all matters connected with the flow of streams, and may be useful for comparison in considering questions of river engineering, we give at the end of this article, in a tabular form, the physical characteristics of different rivers, embracing all the information we have been able to collect, with the sources from whence that information was obtained.

We have considered it necessary to enter thus far into detail, to prepare the way for what is to follow,—*First*, Because it is quite impossible to consider and design with advantage the improvements of a river without a correct knowledge of its physical characteristics, as developed in the course of such investigations as we have described. Such information cannot in every case be procured with an equal amount of precision, but the more complete and detailed it is, the more confidently and advantageously will the engineer proceed to form his design. *Secondly*, We have been particular in defining the physical boundaries of rivers, because the remedial means which call for the engineer's consideration in designing improvements on the three compartments which they include, are not less distinct than the different phenomena which have been described as their peculiar characteristics. In proof of this, it may be stated generally, that the works on the "river proper" section consist chiefly in the erection of weirs, by means of which the water is dammed up so as to form stretches of canal in the river's bed, with cuts and locks between the different reaches. The "tidal compartment" embraces a more varied range, including the straightening, widening, or deepening of the courses and beds of rivers, the formation of new cuts, the erection of walls for the guidance of tidal currents, and in some cases the shutting up of subsidiary channels; while the "seaward compartment" embraces all works connected with the improvements or removal of bars and shoals.

On these subjects we shall have to enter at some length; and in treating of them it may be most convenient to consider the question of river navigation under the three following sections, viz.:—

1*st*. The upper compartment, or "river proper."
2*d*. The intermediate compartment, or "tidal river;" and
3*d*. The lower compartment, or "sea proper."

SECT. III.—THE "RIVER PROPER" DEPARTMENT.

Sizes of rivers proportional to extent of country drained.

The magnitude of a river is, under certain conditions, proportional to the extent of country which is drained, as will be seen by reference to the table at the end of this article, and all our ideas regarding rivers, as affording the means of inland navigation, must necessarily be to some extent varied to meet the different physical characteristics of different countries. Thus, in continents we find rivers of great magnitude, fed by the drainage of vast tracts of surrounding land, rolling their contents in a broad, deep current to the

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ocean, and affording a highway for vessels of the largest class to pursue their course for hundreds of miles into the interior of the country. Of such is the Mississippi, which, according to Mr Ellet, maintains, for a distance of nearly 1200 miles above New Orleans, an average breadth of 3300 feet, and a depth of 115 feet. The Ohio, which joins it at this place, is navigable to Pittsburgh, where the writer of this a ticle has seen from thirty to forty large-sized steamers lying at the quays of that truly inland port, which were all engaged in trading to New Orleans, on the Gulf of Mexico,[1] being a river navigation of upwards of 2000 miles.

In considering the improvement or maintenance of such a navigation as this, the engineer has to deal chiefly with the control of the discharge due to the rains of the district through which the river flows. His difficulty does not so much consist in deficient depth or breadth of navigable channel, as in the magnitude of the floods with which he has to contend, and the provision he has to make for retaining them within such limits as to secure the safety of the surrounding district.

In less extended tracts of country the rivers are proportionally smaller; and when we come to consider our own island, we find that its area and drainage are altogether insufficient to afford depth and breadth of water for extended inland navigation. This will readily be understood when the areas of the basins and the discharges of some of our largest rivers are compared with the Mississippi, to which we have alluded. For example, according to the table to which we have already referred, the Tay drains 2283 square miles, and discharges 274,000 cubic feet per minute; the Clyde drains 945 square miles, and discharges 48,000 cubic feet per minute; the Mississippi drains 1,226,600 square miles, and discharges 76,800,000 cubic feet per minute.

The Mississippi.

It will not, we believe, be considered inappropriate to the subject we are discussing, to offer a short sketch of what is undoubtedly the most gigantic river navigation in the world, taken from the elaborate work by Mr Charles Ellet, on the Mississippi and the Ohio. It appears, from the information given in that work, that the Mississippi varies from 2200 to 5000 feet in width, the average width being assumed as 3300 feet. It is from 70 to 180 feet in depth, the average being 115 feet. The area of the cross section varies from 105,544 square feet to 268,646 square feet, the average being 200,000 square feet. The length, from its junction with the Ohio to the Gulf of Mexico, is 1178 miles, and its average descent at full water is $3\frac{1}{4}$ inches per mile, and in absence of floods (or during summer and autumn) $2\frac{8}{10}$ inches per mile. The length of the Ohio, from its junction with the Mississippi to Pittsburgh (the head of the navigation for large vessels), is 975 miles, and the average inclination is about $5\frac{1}{4}$ inches per mile. From Pittsburgh to Olean Point the distance is 250 miles, and the inclination 2 feet 10 inches per mile. When the water is high, steamboats have ascended to Olean Point, which is 2400 miles from the Gulf of Mexico; and in doing so, have had to overcome a current which at some places runs with a velocity of 5 miles per hour. This, however, is chiefly in the upper part of the river. Generally speaking, vessels have no difficulty, in the lower or more open part of the stream, in avoiding the strength of the currents by keeping in-shore. But in the Ohio much inconvenience is felt during dry seasons from the currents at certain parts of the river; and the writer has seen a steamer, when deeply loaded, unable to overcome them until assisted by a warp attached to an anchor dropped ahead of the vessel, in the middle of the channel, by which, after considerable detention, she was "warped through the rapid." The discharge of the Mississippi is computed by Mr Ellet, at high water, at 1,280,000 cubic feet per second; and its drainage he estimates at 1,226,600 square miles. When the autumnal rains set in, the river rises above its summer level to the enormous extent of about 40 feet at the mouth of the Ohio, and 20 feet at New Orleans. In investigating the physical characteristics of this mighty stream, Mr Ellet found—1*st*, That the average surface velocity in the centre of the river was 5 miles per hour, and occasionally the speed reached 7 miles per hour; 2*d*, By using under-current floats, he found that the speed of a float, supporting a line of 50 feet long, was always greater than that of the surface float—the average increase of velocity being 2 per cent.; 3*d*, The results of the experiments made, lead him to conclude that the mean velocity of the Mississippi is about 2 per cent. greater than the mean surface velocity; 4*th*, In coming to this conclusion, no account is taken of such observations as show remarkable under-currents, the velocity of which were in some places found to be 17 per cent., and $20\frac{1}{2}$ per cent. greater than the surface velocities; 5*th*, While the mass of water which the channel of the Mississippi bears is running downwards with a central velocity, the current next the shore is sometimes found to be running upwards, or in the opposite direction, at the rate of 1 to 2 miles per hour; 6*th*, While the water is running downwards in the one side of the river, it is often found with an appreciable slope, and visible current running upwards on the other side of the river; 7*th*, The surface of the river is therefore not a plane, but a peculiarly complicated warped surface, varying from point to point, and inclining alternately from side to side. After considering all the conflicting results derived from his investigations, Mr Ellet, in order to obtain the mean velocity and discharge of the river, employed the formula as already noticed,—

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$$V = \frac{8}{10}\sqrt{df} + \frac{df}{20}$$

$$M = 0{\cdot}8\ V$$

and $Ma = D$

where V = the velocity of central surface current in feet per second,
d = maximum depth of river in feet at place of observation,
f = slope of surface in feet per mile,
M = the mean velocity in feet per second,
a = area of cross section of river in feet,
D = discharge of river in cubic feet per second.

In discussing the various formulæ for velocities and discharges, we have seen that the formula applied to the Mississippi by Mr Ellet does not apply to such rivers as the Tay, or to smaller water-courses; and until the result which he has given has been compared with the discharge obtained by actual measurement of the velocities at different parts of the cross section, we do not think that the discharge of the Mississippi, which has been calculated by Mr Ellet, can be relied on as accurate.

The chief object of the investigations made by Mr Ellet was the prevention of floods, which have recently increased both in number and extent. This he attributes—

First, To extended cultivation, by which evaporation is supposed to be diminished, the drainage increased, and the floods hurried forward more rapidly into the country below.

Secondly, To the extension of the embankments along the banks of the Mississippi and its tributaries, by which water that was formerly allowed to spread is now confined to the channel of the river.

Thirdly, To what are termed cut-offs, or straight cuts, by which the distance is shortened, and the slope and velocity increased, so that the water is brought down more rapidly from the country above.

[1] *Sketch of Civil Engineering of North America*, by David Stevenson, C.E.

Rivers.

Fourthly, To the gradual extension of the delta into the sea, so as to lengthen the lower course of the river, to diminish the slope and velocity, and thus to throw back the water on the land above.

The works suggested for protecting the country against floods are—

First, More sufficient embankments.

Second, The prevention of further cut-offs, or works for straightening the upper parts of the tributaries of the river.

Third, The enlargement of the seaward channels or outlets; and

Fourth, The creation of large artificial reservoirs, by placing dams across the outlets of the lakes or distant tributaries, so as to compensate for the loss of the natural overflow of the water, which is checked by the embankments for protecting the country in the lower part of the river.

Danube.

An interesting account has been given by Mr Shepherd[1] of certain improvements on the Danube, to which we shall very shortly refer. The navigation of that river was greatly impeded by the constant shifting of its course after every flood. Its channel was divided into numerous branches, and the main object of the improvements was to shut off these lateral branches, and to cause the river to flow in one central channel. This was effected by means of a series of spurs or jetties, made of bundles of brushwood, and thrown out from either side of the river. The brushwood was laid down in its green state, and, taking root, each spur or jetty, after a few years, formed a thick massive hedge, which now prevents the stream from making further ravages on the banks, and confines it to one central channel, scouring out a depth sufficient for navigation. This system of embanking with faggots has been, according to Mr Shepherd, the means of rescuing thousands of acres of land on the Danube, at a cost of not 1s. per acre. These improvements have, it appears, been effected in what were the most dangerous parts of the river, and have, it is stated, in connection with an improved organization of pilotage, been of great benefit to the traffic of the Danube, which is now carried on almost uninterruptedly, it being a very rare occurrence to hear of any of the steamers getting aground.

Circumstances of the Mississippi not applicable to this country.

Although it has been considered proper to allude thus briefly to the large continental rivers, yet it will be obvious that the magnitude of such a river as the Mississippi, for example, prevents us from applying the special results and observations of Mr Ellet to rivers in this country. Indeed, the fresh-water or upper compartments of our rivers are so small, and their navigation is so limited, that we have little to say under that head which can be applicable to the British Isles.

Means of rendering our rivers navigable.

Our streams cannot, like the Mississippi or other large rivers, be advantageously navigated in their natural state; and the means employed to render them navigable may be said to consist in throwing dams across their beds, so as to convert them into a succession of narrow lakes or pools, in which the water is dammed up to such a height as to afford sufficient depth for small boats.

Old stanches.

In early times this was effected by means of what were called "stanches." Sir William Cubitt states that when he undertook the improvement of the Stour in Essex, there were thirteen stanches along the course of the river. These stanches consisted of two substantial posts, which were fixed in the bed of the river, at a sufficient distance apart to permit a boat to pass easily between them, and connected at the bottom by a cross cill. Upon one of these posts was a beam turning on a hinge or joint, and long enough to span the opening. When the "stanch" was used, the boatmen turned the beam (which was above the level of the water) across the opening, and placed vertically in the stream a number of narrow planks resting against the bottom cill and the swinging beam, thus forming a weir which raised the water in the stream about 5 feet high. The boards were then rapidly withdrawn, the swinging beam was turned back, and all the boats which had been collected above were carried by the flow of water over the shallow below. By repeating this operation at given intervals, the boats were enabled to proceed a distance of about 23 miles in two or three days.

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Dams and locks.

This primitive system, which was at one period very common in England, has been superseded by throwing permanent dams across the river, so as to convert its channel into a series of deep-water reaches, and the boats pass from one reach to the other by means of side-cuts with locks. The same plan has been extensively carried out in many of the smaller rivers in America, and is there called "still-water navigation." It has been executed on a pretty large scale by Sir William Cubitt on the upper part of the Severn, where the river has been divided into four reaches, having a depth of 6 feet, with side-cuts and locks having a lift of 8 feet each. The difficulty attending such an operation is the impediment which the weirs present to the passage of the river during floods; but in the case of the Severn this difficulty seems to have been overcome. Sir William Cubitt says the object of these weirs was to raise the water, and to retain it at a proper height for the navigation of the shallow parts of the river, without opposing such barriers as should prevent the free discharge of flood-water; and that this end has been completely answered, there being a depth of 6 feet of water at all times where there was formerly only a depth of 18 inches, and during floods the back-water does not rise higher than before the establishment of the weirs. A similar result may, he believes, be always attained by making the obliquity of the weirs sufficiently great.[2] The same system has also been adopted by the late Mr Rendel and Mr Beardmore, for the improvement of the navigation of the River Lea, an account of which has been communicated by Mr Beardmore to the Institution of Civil Engineers.[3]

The arguments, however, against canals, in consequence of the greater facilities afforded by railways, seem to apply with equal force to the upper compartments of rivers with their dams and locks; and as it is not likely that such a system of inland navigation will receive much extension, we shall, without further detail, proceed to consider tidal navigations which are more intimately connected with the commercial interests of the British Isles, and consequently occupy a more important position in the hydraulic engineering of this country.

SECT. IV.—TIDAL COMPARTMENTS OF RIVERS.

What is meant by the term "tidal."

It is perhaps necessary to preface our observations on this branch of the subject by explaining what is implied by a "tidal navigation," as distinguished from such large fresh-water streams as the Mississippi, or those smaller streams forming the upper compartments of our own rivers, both of which we have been considering. In the former case we saw that the art of navigation is most successfully and extensively practised on the fresh-water streams of the large continental rivers; while in the latter case it was shown that even by the aid of artificial weirs and locks, the largest rivers of this country could only be made navigable for vessels of the smallest class. We learn from this, as has also been stated, that the comparatively limited extent of our isolated country does not afford sufficient area for the collection of so large an amount of rain and spring water as to render our fresh-water streams available for the purposes of navi-

[1] *Civil Engineers' and Architects' Journal*, vol. xii., p. 321.
[2] *Transactions of Institution of Civil Engineers*, vol. v.
[3] Ibid., vol. xiii., p. 241.

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gation. The amount of fresh water which they discharge varies as the river floods rise and fall; and even at its maximum its effects in the lower portion of our estuaries is but feebly felt, as more fully explained hereafter in section vi., under the head of "*Bars*." Our rivers, indeed, may be regarded simply as creeks or inlets, formed and kept open, not by the fresh-water stream alone, but mainly by the action of the tide; and may be said to be navigable only when their channels are filled by the influx of water from the ocean. The great agent, therefore, in keeping open and deepening our navigations is to be found in the tidal flow, which not only scours and maintains the sea channels of our rivers, but also increases their depth of water. Nor is this all: another most important advantage derived from the tides is that upward current due to the tidal rise, which, at first checking and ultimately overpowering and reversing the flow of the ebb-stream, carries vessels to their port, far, it may be, into the interior, without the aid of either steam or wind. This is a view of the subject which cannot fail to strike even the most superficial observer, when he sees, on the Thames or Mersey, for example, a vast fleet of vessels of all sizes, and from all countries, hurried on by the silent but powerful energy of the flowing tide. How invaluable is such an agent to the commercial interests of this country! If, indeed, the action of our river-tides were suspended, it might truly be said of the steam power employed on our railways, that its occupation would be gone. Nor need we do more to enforce the wide-spread interests of the subject than remind the reader that the ports of London, Liverpool, and Glasgow, not to name less important places, are entirely dependent on tidal navigation for their existence.

Its importance.

From what has been said as to the physical boundaries of rivers, it will be apparent that the extent to which this tidal influence is felt varies in different situations. Where the slope of the river is gentle, and the channel is comparatively clear and unobstructed, it is felt far up the river, as in the case of the Thames, where it reaches Teddington Weir, 65 miles from the Nore; and in the Tay, where it reaches its junction with the Almond, 35 miles from the bar. In other cases, such as the Lune in Lancashire, or the Dee in Cheshire, the tidal flow is suddenly checked by artificial weirs erected in the bed of the river for the supply of mills. In a third class of rivers the upward flow of the tide is almost neutralized by the existence of natural obstructions, as in the case of the Erne at Ballyshannon, where it flows only about 3, and the Ness, where it flows only about 6 miles up the river.

Its extent modified by circumstances.

Now, the great object of the engineer, in dealing with what we have termed the "tidal compartment of a river," is to increase the *tidal influence*, or, in other words, to facilitate the *propagation of the tidal wave* through the estuary or river for which he has to design works, and it will be found in the examples we have hereafter to offer that, with proper management, this desirable improvement may be surely accomplished, and its amount accurately determined. But that the subject may be fully understood, it is necessary that we should in the outset explain the nature and laws of "tidal propagation" and "tidal currents"—phenomena attending the tides of our rivers and estuaries which must be duly recognised and estimated in all designs for improvements which are based on sound principles of river engineering.

The object of all improvements is to increase it.

The tidal wave which enters an estuary is a branch of the great tidal wave of the ocean. Mr Scott Russell was the first experimental inquirer who conducted investigations on the tide wave of estuaries. Mr Russell's observations were made on the Dee in Cheshire, and the Clyde, and the results which he obtained may be briefly stated as follows:—

The tidal wave.

1. The great primary wave of translation differs from every other species of wave in its origin, its phenomena, and its laws.

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Laws of its propagation.

2. The tide wave is *identical* with the great primary wave of translation.

3. In a rectangular channel, the velocity with which the tidal wave is propagated is equal to the velocity acquired by a heavy body falling freely by gravity through a height equal to half the depth of the fluid, reckoned from the top of the wave to the bottom of the channel. In a sloping or triangular channel the velocity is that of a gravitating body due to $\frac{1}{2}$d of the greatest depth. In a parabolic channel the velocity is that due to $\frac{8}{9}$ths or $\frac{32}{35}$ths of the greatest depth, according as the channel is convex or concave. And generally *the velocity is that due to gravity, acting through a height equal to the depth of the centre of gravity of the transverse section of the channel below the surface of the fluid.*

4. The velocity in channels of uniform depth is independent of their breadth.

5. A tidal *bore* is formed when the water is so shallow that the first waves of flood move with a velocity so much less than that due to the succeeding parts of the tidal wave as to be overtaken by the subsequent parts, or whenever the tide rises so rapidly that the height of the first wave of the tide exceeds the depth of water at that place.

6. A wave of high-water of spring tides travels faster than a wave of high-water of neap tides.

These laws are supposed to apply to the passage of the wave through channels having a pretty uniform depth and form of cross section; but the very irregular outline of the beds of most of our tidal channels renders it almost always difficult, and in many cases impossible, to apply them rigidly to cases which occur in actual practice. The writer may, however, state generally, in corroboration of the correctness of Mr Russell's deductions, that after investigating the tidal phenomena of many estuaries and rivers, he has found that in all cases the quickest propagation of the tidal wave occurs at those places where there is the greatest average depth; but the varying outline of the cross section renders it almost impossible, in most cases, to determine what is the *ruling depth* for calculating the rates of propagation in any particular section of the river. In the Dornoch Firth, to which we have already alluded, the writer found that the distance of 11 miles between Portmahomac and Meikleferry is traversed by the tide-wave in thirty minutes, giving a velocity of 22 miles per hour. The depth of the water of that part of the firth varies from 9 to 50 feet. Between Meikleferry, again, and the Quarry, a distance of 8 miles, where the depth is much less, varying from 6 to 20 feet, the transit of the wave occupies 65 minutes, giving a speed of 6·4 miles per hour.[1] Between the Quarry and Bonar Bridge, a distance of 1 mile, the water is comparatively shallow, varying from 1 to 3 feet, and the rise on the bed of the river is very rapid. In consequence of these obstructions, the tide does not appear at Bonar Bridge for an hour and a half after it has appeared at the Quarry, giving a rate of propagation of only two-thirds of a mile per hour. From observations made by the writer at the Dornoch Firth and elsewhere, it appears evident that, in addition to the elements on which the laws of propagation as quoted are based, the slope on the surface of the stream in tidal rivers affects to some extent the rate of propagation, independently either of the depth or cross-sectional form of the channel; but it will be more convenient to notice this at a subsequent part of this treatise.

Obstacles which operate in retarding tidal wave.

Now, the obstructions which are most frequently found to operate as retarding influences are, the circuitous routes of the channels of rivers, inequalities in their beds, the pro-

[1] The times are the intervals which elapse between the first appearance of the tide at the different stations.

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jection of obstacles from their banks, and in certain circumstances the slopes of their surfaces. The combined effect of these obstructions is such as in all rivers to check the propagation of the tide-wave; and in situations where there is a great and rapid rise of tide, to heap up the water in the lower part of the river, and so to occasion what are termed "bores," and other apparent anomalies. In the Dee, for example, there is at low-water a fall of 11 feet from Chester to Flint, a distance of 12 miles; and on one occasion the writer found that after the tide had risen 18 feet 4 inches at Flint, it had not commenced to flow at Chester. While, therefore, at low-water there is a fall seawards of 11 feet from Chester to Flint, there was at the time alluded to a fall from the sea downwards, so to speak, of no less than 7 feet 4 inches from Flint to Chester. Fig. 2 is a diagram

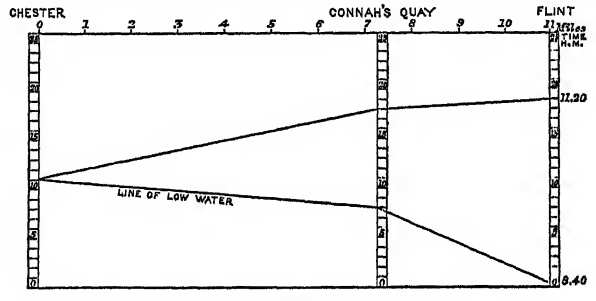

Fig. 2.

of these tide lines, which will illustrate more clearly the effect of this heaping up of water in the seaward part of the river. The lower line represents the surface of low-water, and the upper line shows the surface at the period of flood-tide to which we have alluded.[1] In this case the small depth of water, and tortuous and unequal channel, retarded the early waves of flood-tide so much, that they were overtaken by the succeeding waves; and, in accordance with Mr Russel's theory, a *tidal bore* was the result, or, in other words, the water was heaped up so high, and the slope was consequently so great, as to cause the water

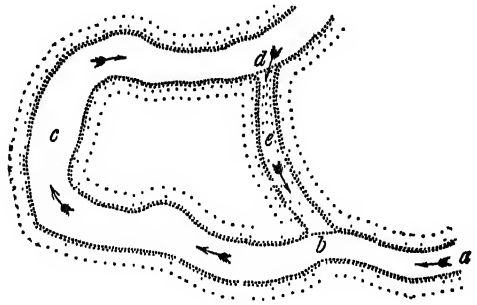

Fig. 3.

to tumble over, and ascend the river in the form of a breaking wave.

Rivers.

The manner in which such tides flow up an estuary may be explained by a simple illustration. In fig. 3 the letters *a, b, c, d* represent a part of the low-water channel of the River Dee, at a place where the estuary is about 3 miles wide, and consists of extensive sand-banks. In examining minutely the windings of the stream in reference to certain investigations, it was necessary to walk down the right bank of the river at low-water, close to the edge of the channel. While so engaged, the writer crossed at the point *b*, a hollow in the sand-bank, which, though depressed below the general height of the surrounding surface, was nevertheless quite dry, the lowest part of the track being considerably above the level of the water of the river. Crossing this hollow, the noise of the approaching tide was heard; and expecting to meet the flood forcing its way up the river, he continued to walk on; but seeing no appearance of its approach by the proper channel, and still hearing the noise gradually increasing, and apparently coming from behind, he turned round and perceived a rapid run of water flowing (in the direction shown by the arrow) through the hollow *deb*, which had just been crossed, and emptying itself into the river at *b*. He immediately hastened back, and after having waded through the newly-formed stream at *b*, which had attained a depth of 6 or 8 inches, he remained on its upper side to see the result of this unexpected inroad. The water continued to rush through the hollow, rapidly gaining breadth and depth, and at last, after an interval of 2 or $2\frac{1}{2}$ minutes from the time at which the noise was first heard, the tide appeared forcing its way up the proper channel of the river with a head or bore of 6 or 8 inches in height. In this case it is clear, from what has been said as to the slope on the river from Flint to Chester during the early periods of tide, that the level of the water at *d* in the diagram would be above that at *b*. The tide, on arriving at the point *d*, would be naturally divided into two branches or currents, one proceeding up the natural channel towards *c*, and the other flowing into the hollow in the sand-bank at *d* towards *e*; and as the level of the water at *d* rose, the stream which flowed into the hollow in the sand-bank would gradually rise higher until it surmounted the summit-level at *e*, after which it would rush from *e* to *b* without obstruction. The other branch of the tide would in the meantime be forcing its way along the circuitous channel *dcb*, which was about a mile in length; and before it reached *b*, the water at *d* had attained a much higher level than at *b*, and having surmounted the summit-level of the sand-bank at *e*, continued to flow without obstruction into the channel of the river in the manner represented. Thus in all places where the retarding influences which exist in the regular channel of the river exceed the obstructions in any *back lake* or *swash-way*, the tide will flow sooner through the latter than the former, and give rise to an apparent anomaly such as has been described.

Example of a tidal bore on the Dee.

The late Admiral Beechey, in his *Remarks on the Tidal Phenomena of the River Severn*, published in 1851, gives

Bore on the Severn.

[1] The writer has found, that in all cases the heaping up of the water increases with the rise of tide, being greatest in spring and least in neap tides; as will be seen from the following tabular views of the maximum difference of level between the surface of the water at Flint and Chester on the Dee, and (to offer another example) at Glasson and Lancaster on the Lune, during the flow of tides of various amounts of vertical range.

River Dee.			River Lune.		
Date.	Rise of tide at Flint.	Maximum fall from Flint to Chester.	Date.	Rise of tide at Glasson.	Maximum fall from Glasson to Lancaster.
1839.	Ft. in.	Ft. in.	1838.	Ft. in.	Ft. in.
May 21	14 0	3 8	Aug. 29	12 1	1 1
„ 23	15 6	4 5	„ 31	12 9	1 6
„ 25	16 4	5 8	Sept. 1	15 4	2 0
„ 29	18 0	6 6	„ 3	19 8	2 10
June 10	19 8	7 10	„ 5	23 2	3 2
			„ 6	23 6	4 4

Rivers.

the following interesting account of the bore on that river:—"The bore," he says, "is not dangerous to boats if afloat in the middle of the river; and it is the common practice up the Severn to row the boats out to the centre of the stream on the approach of the bore, and put their head to the wave; but if this precaution be not taken, and the boats are allowed to remain at the edge of the shore, they are liable to be swamped or stove, as the waves break with great violence along the banks as it proceeds; but towards the centre of the river, if the water be not very shallow, the wave is smooth and unbroken. Before the arrival of the bore, the stream runs down the river, and the altitude of the water at a distance from the sea is quite stationary; but on the arrival of the bore, the water instantly rises according to the height of the breast of the wave, and the stream turns and follows the wave up the river, although it had but a few minutes before been running down at a rapid rate; and this change of stream is effected without any breaking wave. When there is a heavy fresh down the river, and the stream is running at the rate of four or more miles an hour, the upward stream hangs for several minutes after the bore has passed, not being able to overcome at the moment the impetus of the ebbing water; but when it has once turned upwards, it attains its maximum speed in the first half hour of the tide. When the reaches of the river are straight, the bore travels evenly up the river, but at the turnings it is thrown off towards the further side, where it rises higher than in the straight reaches; thence it recoils and impinges upon the opposite shore, and so, like a disturbed pendulum, it oscillates from side to side, and only regains its steady course when the reaches lengthen. The highest tide of the year rolled up the Severn on the 1st of December. There was about 2 feet of water above the ordinary summer-level in the river, and the morning was calm and favourable to the phenomenon. The stream at low-water ran down at the rate of 2½ miles (geographical) per hour, until the time when the bore came rolling up the river with a breast from 5 to 6 feet high at the sides, and 3 feet 6 inches in the centre. The wave was glassy smooth; and as it advanced towards a spectator stationed at Stonebench, a singular effect was produced by the distorted surface of the wave reflecting the rising sun, and brilliantly illuminating the stems and branches of the wood skirting the river as the bore passed along—an effect which greatly enhanced the interest of the phenomenon, which is at all times an object of curiosity. The stream turned up the instant after the bore passed, and ran at the rate of 3¾ miles per hour, which was about half the average rate of the bore, the speed of which varied from 12 to 7 miles per hour, averaging 8 between Stonebench and Gloucester." Admiral Beechey further says, "that the effect of a fresh, or a certain depth of water in the river, upon the advance of the bore is remarkable. At dry periods the great obstruction to the progress of the bore lies between Sharpness and Bollowpool, and at such times the many dry sand-banks prevent the bore attaining a rate greater than about 4 miles an hour; but when the river is under the influence of freshes, and the water raised and covering some of the banks, it appears to roll on at a rate of 10 miles an hour in opposition to the stream, which runs down at the rate of upwards of 4 miles an hour."

Tide currents.

But the passage of the tidal-wave through an estuary or river, must not be mistaken for what is called the "tide current," which is a totally different phenomenon. The tidal-wave which we have been describing as passing through the lower part of the Dornoch Firth, for example, at the rate of 22 miles per hour, is not the current due to the flowing tide by which vessels are carried across the bar, and borne onward to their destination. That current flows with a velocity which at the Dornoch Firth does not exceed 4 or 5 miles per hour; a velocity which, indeed, is not often exceeded, excepting in such rapid tideways as the Severn, at the New Passage, where the velocity is said to reach 9 miles per hour;[1] and in the Pentland Firth, where Captain Otter measured a velocity during ebb-tide of no less than $10\frac{6}{10}$th nautical miles per hour,[2] being, so far as we know, the greatest tide velocity on record. The laws of the propagation of the tidal wave, to which we first alluded, depend, as explained, on circumstances somewhat obscure; but the velocity of the tide current, or that current which flows into our rivers, and affects the transit of shipping, is due *entirely* to the *slope* or *fall* on *the surface of the water*. The amount of this slope has been shown to be dependent on the rapidity with which the tide rises, and the amount of obstruction presented to its propagation up the river. The more rapid the rise of tide, and the greater the obstruction to its flow, the higher will the tide-wave at certain parts of a river or estuary be heaped up. A head of water is thus formed whose height is due to the rapidity of the rise of the tide and the obstruction to its progress; and a flow of water having a velocity due to that head is generated up the river or estuary, and this flow of water is what we term the *tide current*.

Rivers.

This is probably the most convenient place to notice some facts of great importance in river engineering, which we deduce from these considerations, as to the nature of the tidal propagation and tide currents. The obstructions to which we have alluded *retard* the rate of propagation, but by raising the head, they *increase* the velocity of the tide currents. Now, as the aim, and, if successful, the effect of all engineering works, is to increase the rate of tidal propagation, no less certainly will they tend to lessen the heaping up of water in the lower reaches, and at the same time to *decrease the velocity of the tide currents*. In cases where these currents are found to act prejudicially by producing a bore, or by bringing up sand from the lower parts of the estuary, or where they are inconveniently rapid for navigation, we are thus, while increasing the propagation of the tidal wave, enabled to check their energy, and thus to effect an important improvement.

By increasing the rate of tidal propagation we decrease the velocity of the tidal currents.

Another important circumstance is worthy of notice at this place. It is well known that the momentum of the column of water, flowing up the gradually contracting and rising channel of a river, causes the level of high-water to stand higher than in the open ocean or in the lower reaches. This is accounted for, as already stated, on the principle of the conservation of forces. The height to which the water is thus raised depends on the quantity of water thrown in by the tide during a given time, the elevation being greatest at spring, and smallest at neap tides. At the Dee, for example, the writer found that the high-water of spring tides at Chester was 14 inches higher than that at Connah's Quay; while at neap tides the difference of level was only 4 inches. Now, the effect of engineering works, as will be more fully detailed hereafter, is not only to produce a free propagation of the tide, but to admit a larger body of tidal water; and it has been contended that such operations must necessarily cause the tide to rise higher, and it has been attempted to be shown that they might in some situations occasion inconvenience, and even injury to property, in consequence of the overflowing of the river's banks. After the most careful observation, however, the writer has not been able to detect that such operations have in any case had the effect of appreciably raising the level of the high-water line. Although the tide in improved rivers begins to flow earlier, and a much larger body of

The level of high-water not raised by facilitating tidal propagation.

[1] *Report to the Admiralty on the Severn Improvement Bill*, 1849, by Captain Vetch.
[2] *Admiralty Survey of Pentland Firth*, by Captain Otter, Admiralty coasting pilot.

Rivers.

water is thrown up the river, still, in conformity with the views already stated, the velocity with which the water flows is decreased, so that the momentum of the column of water remains nearly the same, or at least is not so notably altered as sensibly to increase the height to which the high-water rises; and by this fortunate compensative action our rivers, though their beds are opened up and improved, do not inundate our towns or even overflow our quays, but quietly keep within their original limits.

Removal of obstructions to tidal flow.

The removal of all obstacles to the flow of the tide is the object, as already stated, to which the engineer has chiefly to direct his attention in designing improvements in the department of navigation now under consideration; and it may be stated, that in order to form a satisfactory opinion on this matter, it is essential to have an accurate survey, showing the depths of water and the breadths of channel throughout the whole extent of the river, and also to ascertain the amount of tidal range, the velocity of the currents, the rise on the bed, and the nature of the materials of which the bottom and banks are composed. Possessed of this information, he is in a position to consider to what extent the bed of the river may with advantage be deepened and widened, and the currents directed by means of walls; also if subsidiary channels may with safety be shut up, or new cuts be made for the passage of the river, or whether or not irregularities in the width which injuriously affect the currents may be corrected. In all these matters the engineer must, in each particular case, be guided by experience. While it is therefore impossible, in such circumstances to specify works which shall be of *universal* application, it is nevertheless quite within the range of sound engineering advice to point out *generally* the works which are most likely to effect improvements, and to direct the reader to cases in which such works have proved successful; and this is all that we propose to do in the remarks we have to offer on this part of our subject.

With reference to these operations, then, it may be stated, that all obstructions which prevent the extension of the tidal influence up the river may safely be taken away, and their removal may confidently be expected to be followed by highly beneficial effects. It is necessary to remark, however, that the removal of artificial weirs erected for the purposes of manufacture is, in many cases, attended with difficulty, arising from the value of the interests involved, which are sometimes so great that the abolition of such erections cannot be effected without large compensation. The weirs on the Dee in Cheshire, and the Lune in Lancashire, are instances of this, being productive of much injury; while in both cases the interests affected are so important, and the consequences so serious, as hitherto to have operated as an effectual barrier to their removal. The removal of existing quays and other works of long standing, as in the case of the Thames, the Tyne, and the Wear, is also for the same reason difficult, and works must therefore be designed for such localities which shall not injuriously affect existing interests. But all natural weirs or shoals, consisting of fixed rock or hard gravel, which cannot be disturbed by the action of the current, as well as all projections into the stream, where unattended by the difficulties alluded to, should at once be removed. Whenever it is possible, divided currents should be united into one stream. The channel, where it is necessary, should be guided by longitudinal walls, and the river's bed should be deepened to the full extent compatible with a due amount of slope being left on the surface.

These may be said to be the safest and most beneficial works which can be adopted in designing river improvements, their effect being to cause the currents of flood and ebb tide to flow always in one channel, and thus to exert their full and combined power in keeping open one navigable track. The manner in which they are executed demands a few remarks; and we shall treat the different works under the heads of:— Rivers.

1. Removal of lateral obstructions.
2. Closing subsidiary channels.
3. Dredging.
4. Excavation.
5. River walls; and
6. Scouring.

1. *Removal of Lateral Obstructions.*

Under the "Removal of Lateral Obstructions" may be classed all those works which have for their object the formation of proper outlines for the banks or sides of the river. In the early history of river engineering it was not uncommon to construct jetties or groins projecting from the banks on either side, with the view of narrowing the stream and producing a greater scouring power to operate on the bottom. It is no doubt true, that such projections have the effect of producing a *local* acceleration of the currents, and in soft bottoms a corresponding increase of depth in their immediate vicinity. But this increase of velocity and depth being due entirely to the obstruction and consequent raising of the level of the water caused by the jetty, is strictly local. Whenever the water passes the head of the jetty, it expands into the greater width of bed, the head is reduced, a stagnation or eddy takes places, and a bank or shoal is formed,—a result which invariably follows the projection of any obstruction or foreign body into a stream having a soft bottom. As an aggravated instance of the effect of such obstructions, we may refer to the case of a vessel of about 170 tons, which, in consequence of the breaking of a towline, grounded at the side of the River Tay when there was some flood in the river. The effect is shown in fig. 4, where the vessel is represented at a as lying in a pool which was scoured to the depth of about 10 feet in the course of a few tides; and the gravel thus excavated by the current, acting on the grounded vessel, and amounting to upwards of 1000 tons, was deposited in the form of a bank, 5 feet above low-water, immediately below the pool, as shown in hatched lines. A similar effect, though varying in degree, occurs in all rivers confined by jetties. The beds of rivers so treated consist of an alternation of shoals nearly dry at low-water, and pools of a depth far greater than is actually requisite, instead of presenting, as they ought to do, a regular bottom and a uniform depth of water available for the purposes of navigation. Examples of the prejudicial effect of jetties are to be met with in the history of the Clyde, the Ribble, the Dee in Cheshire, the Tay, and, the writer believes, with little or no exception, in every situation where the system of contracting, or even directing the currents by means of such works, has been generally adopted. From the Clyde, the Ribble, and the Tay they have been entirely removed. The writer has invariably found, that whenever jetties existed, their entire or partial removal formed one of the first steps towards an improvement of the navigation, and this course has, in all cases which have come within his experience, been followed by good results. In some instances, where the river is contracted by the projection of quays or by the natural formation of the banks, it is desirable, where it can be done consistently with existing interests, to enlarge the cross-sectional area, in order to reduce the velocity of the currents and prevent disturbance of the tidal flow.

Jetties objectionable.

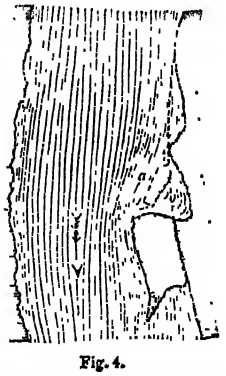

Fig. 4.

Rivers.

2. *Closing Subsidiary Channels.*

The next work to be noticed is the closing of what we term subsidiary channels. These are channels, or, as they are sometimes called, *back lakes*, caused by islands which divide the stream and reduce its scouring power. The consequence is, that instead of flowing in one broad, deep, navigable bed, kept open by the whole available scouring power, the river is divided into two shallow channels, neither of them affording a good navigation, while frequently a ford or shallow is occasioned both above and below the island by the disturbance which occurs at the junction of the divided currents. On the Tay and the Lune several such secondary channels were, with much advantage to the navigation, closed up by means of embankments formed of gravel dredged from the river, while the other or principal channel was enlarged and deepened, so as fully to compensate for the closing of the smaller channel, and assimilate its cross-sectional area to the rest of the navigable track.

3. *Dredging.*

The introduction of mechanical appliances for the purpose of excavating materials under water, raising them to the surface, and depositing them in barges, was an important era in canal and river engineering. The first employment of machinery to effect this important object is, like the discovery of the canal lock, claimed alike for Holland and Italy, in both of which countries dredging is believed to have been practised before it was introduced into Britain. The moving power at first employed in conducting the process was manual labour, but in all large works dredging is now performed by steam, and is probably the most effective and generally applicable means of improvement at the command of the engineer. The Dutch, at a very early period, employed what is termed the "bag and spoon" dredge for cleaning their canals. It consisted of a ring of iron about 2 feet in diameter, flattened and steeled for about one-third of its circumference; to this ring a bag of strong leather was attached by means of thongs, and the whole apparatus was fixed to a long pole, which, on being used, was lowered to the bottom from the end of a barge moored in the canal or river. A rope made fast to the iron ring was then wound up by a windlass placed at the other end of the barge, and the spoon was thus dragged along the bottom, and was guided in its progress by a man who held the pole. When the spoon reached the end of the barge where the windlass was placed, the winding was still continued, and it was raised to the surface, bringing with it the stuff excavated, and deposited in the bag during its progress along the bottom. The windlass being still wrought, the whole was raised to the gunwale of the barge, and the bag being emptied, was again lowered and hauled back to the opposite end of the barge for another supply. This system is slow, and only adapted to a limited depth of water and a soft bottom. It has, however, been generally employed in canals, and was much used in the Thames; and the writer, in one situation where, from want of space and other peculiarities, more perfect mechanical means could not be employed, used it to a pretty large extent, the quantity raised being about 135,000 tons. The process, although tedious, was very convenient, and the cost of raising the materials did not exceed 7½d. per ton. Another plan practised at an early period was to moor two large barges, one on either side of the river; between them was slung an iron bucket or box, attached to both barges by chains wound round the barrels of a powerful crab-winch in one barge, and round a capstan in the other. The bucket was lowered at the side of the barge in which was the capstan, and being drawn across the bottom by the crab in the opposite barge, was raised and emptied; after which it was again lowered, and hauled across by the capstan for a repetition of the process. But in all large operations these and other primitive appliances have, as already stated, been superseded by the steam-dredge, which was first employed, it is believed, in deepening the Wear at Sunderland, about the year 1796. This machine was made for Mr Grimshaw by Bolton and Watt.[1] Receiving improvements from Mr Hughes, Mr Rennie, Mr Jessop, and others, the steam-dredge, as now generally constructed, is a most efficient machine, excavating and raising materials from the depths of 15 to 20 feet of water, at a cost not very different from that at which the same work could be performed on dry land.

For details as to the construction of steam-dredges, we have to refer to the articles in *Weale's Quarterly Papers*, already quoted. As to the nature and extent of work performed by them, we may state generally, that almost all materials, excepting rock or very large boulders, may be dredged with ease. Loose gravel is probably the most favourable material to work in; but a powerful dredge will readily break up and raise indurated beds of gravel, clay, and boulders. In such cases it is usual to alternate on the bucket-frame, a bucket of sheet-iron for raising the stuff, with a rake or pronged instrument for disturbing the bottom. Hand-dredges have been used by Messrs Stevenson at several harbours, by means of which, even disintegrated or rotten rock has been easily raised; and the writer believes, that in very many cases the surfaces of submerged rocks near the mouths of harbours may, by means of such machines, be broken up and removed, so as to obtain in certain situations a considerable increase of depth, without recourse to coffer-dams, which, on exposed coasts, involve great expense and sea risk, as well as interruption to the trade. These small dredges are worked by eight or ten men, and cost about £350.

A well-constructed steam-dredge of 16 horse-power will, under favourable circumstances, raise about 140 tons of stuff per hour. The excavated materials are first discharged into lighters or barges, and then deposited in any convenient position, where they are sufficiently removed from the risk of being carried off by floods, and again thrown into the bed of the river.

In some cases the discharge is made into hopper punts or barges, which are floated out to sea, and the stuff is dropped in deep water. The cost of steam-dredging varies according to the nature of the materials and the circumstances of working, as regulated by the tides and the distance of deposit. It has, in the writer's own experience, varied from 4d. to 6d. per ton, or from 5½d. to 8d. per cubic yard, including all expenses.[2] We believe that in no place has steam-dredging been more extensively used than in the Clyde, where the navigable depth has been increased and is maintained mainly by that process. The following details as to the dredging on that river are given in a communication made to the Institute of France by the late Mr William Bald, who acted as resident engineer on the Clyde.[3] Mr Bald says, that annual dredging to the amount of from 160,000 to 180,000 tons was necessary at the time he wrote, in order to maintain the navigable depth of water in the Clyde in the 18 miles from Glasgow seawards. In execut-

[1] *Encyclopædia of Civil Engineering*, by Edward Cresy, London, 1847; "The Dredging Machine," *Weale's Quarterly Papers*, part I., London, 1843; *The Improvement of the Port of London*, by R. Dodd, Engineer, 1798.

[2] It was found on the Tay that 18 cubic feet of gravel weighed 1 ton.

[3] *Civil Engineers' and Architects' Journal* for August 1845.

Rivers. ing this work, the river trustees employed 5 dredges, a steam-tug, 2 diving-bells, and 160 punts; the whole value of the working machinery being about L.39,000. The following table gives the details of the dredging-machines:— Rivers.

No. of Dredge.	When she commenced to work.	Greatest depth of Working.	Least depth of Working.	Diameter of Cylinder.	Length of Stroke.	Number of Buckets.	Length of Bucket-frame.	Nominal Power of Engine.
		Ft. in.	Ft. in.	Inches.	Ft. in.		Ft. in.	Ho.-power.
1	1824	10 6	3 9	21	2 6	31	47 9	12
2	1826	14 0	4 0	24	2 6	33	52 11	16
3	1830	14 0	4 0	24	2 6	33	52 11	16
4	1836	15 6	4 3	26	2 6	34	54 7½	20
5	1841	17 to 19 ft.	4 4	27½	2 6	34	58 0	22

All these dredges had governors, which regulated the speed to about 28 strokes per minute in ordinary working stuff. The average pressure in boilers was about 3½ lb. per square inch. In general, 14 buckets were discharged per minute. The speed of the buckets on the frames of dredges Nos. 1, 2, 3, and 4, was 48 feet 5 inches per minute, and that on No. 5, 49 feet 8 inches per minute. They consumed from 15½ to 18 lb. of coal per horse-power per hour. The following is a statement of the amount of work which was performed by these dredges, and the expense of the process:—

Year ending	Amount expended.	Work executed.	Rate per Cubic Yard.
	L. s. d.		L. s. d.
December 25, 1841....	11,841 18 2	218,110	0 1 1
... 24, 1842....	13,612 11 3	313,810	0 0 10½
... 23, 1843....	9,742 7 6½	294,440	0 0 8
... 21, 1844....	10,659 3 8	317,660	0 0 8

Tabular View of the Dredging of the Wear at Sunderland in 1842–46.

Date.	Total Quantity Raised per Annum.	Expenditure in Labour for Raising and Depositing per Annum.	Expense of Fuel per Annum.	Expenditure in Labour for Repairs per Annum.	Expenditure in Materials for Repairs per Annum.	Total Expenditure per Annum.	Average cost per Ton on the Year's Expenditure.
	Tons.	L. s. d.	L. s. d.	L. s. d.	L. s. d.	L. s. d.	Pence.
1842	128,245	922 1 2	111 0 0	754 16 0	704 17 11	2492 15 1	4·665
1843	141,325	879 16 0	70 0 0	503 13 4	786 13 11	2240 3 3	3·804
1844	90,980	567 13 4	66 5 9	259 2 1	563 9 10	1456 11 0	3·842
1845	101,075	721 9 0	66 7 6	336 8 0	527 7 10	1651 12 4	3·921
1846	140,350	724 5 4	58 2 5	500 17 2	520 3 2	1803 8 1	3·083
	Hence the average cost per ton on five years' work—						
1842 to 1846	For raising and depositing at sea						= 1·528
	For fuel						= 0·149
	For labour in repairs						= 0·943
	For materials to ditto						= 1·243
	Average total Expenditure						= 3·863

Mr Murray gives the above tabular view of the dredging of the Wear at Sunderland, which is also an interesting record of the quantity and cost of material raised by a dredging-machine; but this view is not given by way of comparison with the preceding, as there is little analogy between the cases. The contracted state of the Clyde, the frequent interruptions to which the work was subject by the constant passage of vessels, and the expense of removing and depositing the stuff, necessarily increased the cost of executing the work in that situation.

In river-dredging two systems are pursued; one plan consists in excavating a series of longitudinal furrows parallel to the axis of the stream, the other in dredging cross furrows from side to side of the river. It is found that inequalities are left between the longitudinal furrows, when that system is practised, which do not occur to the same extent in side or *cross-dredging;* and the writer has invariably found cross-dredging to leave the most uniform bottom. To explain the difference between the two systems of dredging, it may be stated, that in either case the dredge is moored from the head and stern by chains about 250 fathoms in length. These chains in improved dredges are wound round windlasses worked by the engine, so that the vessel can be moved ahead or astern, by simply throwing them into or out of gear. In longitudinal dredging, the vessel is worked forward by the head chain, while the buckets are at the same time performing the excavation; so that a longitudinal trench is made in the bottom of the river. When the dredge has proceeded a certain length, it is stopped and permitted to drop down and commence a new longitudinal furrow parallel to the former one. In cross-dredging, on the other hand, the vessel is supplied with two additional moorings, one at either side, and these chains are, like the head and stern chains, wound round barrels wrought by the engine. In commencing to work by cross-dredging, we may suppose the vessel to be at one side of the channel to be excavated. The bucket-frame is set in motion, but instead of the dredge being drawn forward by the head chain, she is drawn to the opposite side of the river by the side chain, and having reached the extent of her work in that direction, she is then drawn a few feet forward by the head chain; and the bucket-frame being yet in motion, the vessel is hauled back again by the opposite side chains to the side from whence she started. By means of this transverse motion of the dredge, a series of cross furrows is made; she takes out the whole excavation from side to side as she goes on, and leaves no protuberances such as are found to exist between the furrows of longitudinal dredging, even where it is executed with great care. The two systems will be best explained by reference to the annexed cut (fig. 5), where AB repre-

Cross-dredging.

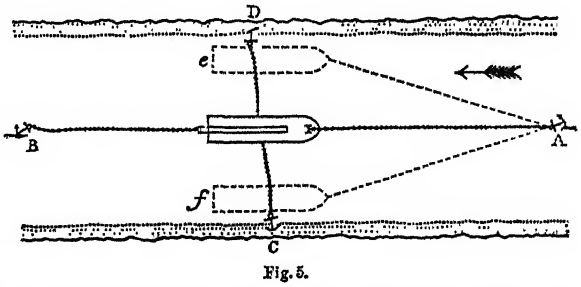

Fig. 5.

sents the head and stern moorings, and DC the side moorings; the arc *ef* represents the course of the vessel in cross-dredging; while in longitudinal dredging, as already ex-

Rivers.

plained, she is drawn forward towards A, and again dropped down to commence a new longitudinal furrow.

In some cases, however, the bottom is found to be too hard to be dredged until it has been to some extent loosened and broken up. Thus at Newry, Mr Rennie, after blasting the bottom in a depth of from 6 to 8 feet at low-water, then removed the material by dredging, at an expense of from 4s. to 5s. per cubic yard. The same process was adopted by Messrs Stevenson at the bar of the Erne at Ballyshannon, where, in a situation exposed to a heavy sea, large quantities of boulder stones were blasted, and afterwards raised by a dredger worked by hand, at a cost of about 10s. 6d. per cubic yard. But the most extensive application of blasting, preparatory to dredging, of which the writer is aware, was that on the works for improving the Severn, by Sir William Cubitt, of which an interesting and instructive account is given by Mr George Edwards, in a paper addressed to the Institution of Civil Engineers, from which the following particulars are taken:[1]—

"It appears that a succession of marl beds, varying from 100 yards to half a mile in length, were found in the channel of the Severn, which proved too hard for being dredged, the whole quantity that could be raised being only 50 or 60 tons per day; while the machinery of the dredges employed was constantly giving way. Attempts were first made to drive iron rods into the marl bed, and to break it up; a second attempt was made to loosen it by dragging across its surface an instrument like a strong plough. But these plans proving unsuccessful, it was determined to blast the whole surface to be operated on. The marl was very dense, its weight being 146 lb. per cubic foot;[2] and it was determined to drill perpendicular bores, 6 feet apart, to the depth of 2 feet below the level of the bottom to be dredged out. The bores were made in the following manner, from floating rafts moored in the river:—Pipes of $\frac{3}{16}$-inch wrought-iron, 3½ inches diameter, were driven a few inches into the marl. Through these pipes holes were bored, first with a 1½-inch jumper, and then with an auger. The holes were bored 2 feet below the proposed bottom of the dredging, as it was expected that each shot would dislocate or break in pieces a mass of marl of a conical form, of which the bore-hole would be the centre and its bottom the apex; so that the adjoining shots would leave between them a pyramidal piece of marl, where the powder would have produced little or no effect. By carrying the shot-holes lower than the intended dredging, the apex only of this pyramid was left to be removed; and in practice this was found to form but a small impediment. Fig. 6 is a section, and

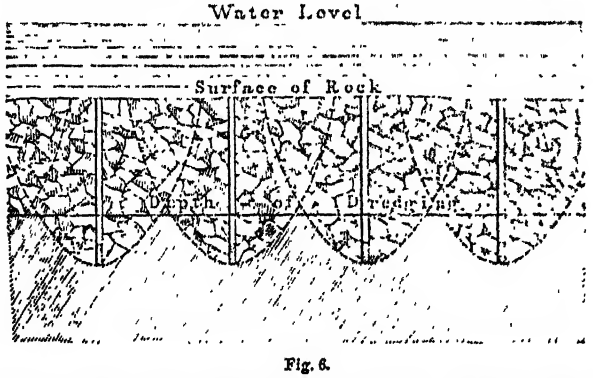

Fig. 6.

fig. 7 a plan of the bore-holes; the inner dotted circles represent the diameters of the broken spaces at the level of the bottom of dredging. The cartridges were formed in the ordinary way, with canvas, and fired with Pickford's fuse. The weight of powder used for bore-holes of 4 feet, 4 feet 6 inches, and 5 feet, were respectively 2 lb., 3 lb., and 4 lb. The effect of the shot was generally to lift the pipes a few

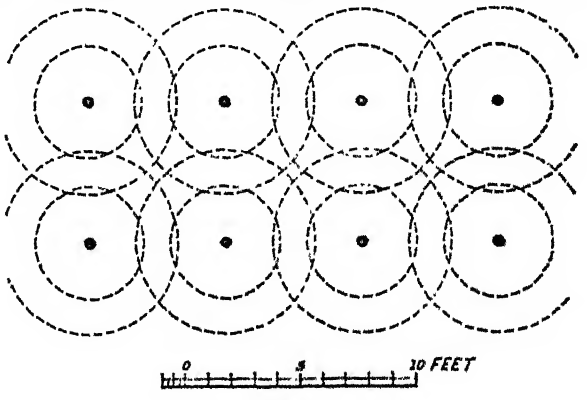

Fig. 7.

inches, which were secured by ropes to the rafts. Mr Edwards says that not one in a hundred shots missed fire, and these shots were generally saved by the following singular expedient:—The pointed end of an iron bar, ¾-inch diameter, was made red-hot, and being put quickly through the water, and driven through the tamping as rapidly as possible, was in nine cases out of ten sufficiently hot to ignite the gunpowder and fire the shot.

"The cost of each shot is calculated as follows:—

	£	s.	d.
Use of material	0	1	0
Labour	0	3	3
Pitched bag for charge	0	0	3
3 lb. of powder at 5½d.	0	1	4½
15 feet of patent fuse at $\frac{5}{6}$ths of a penny	0	0	9
Pitch, tallow, twine, coals, &c.	0	0	4½
Cost per shot	£0	7	0

Each shot loosened and prepared for dredging about 4 cubic yards; so that the cost for blasting was 1s. 9d. per yard. The cost of dredging the material, after it had been thus prepared, was 2s. 3d.; making the whole charge for removing the marl 4s. per cubic yard."

4. *Excavation.*

But there are cases where the bottom cannot be advantageously operated on by any of the means we have mentioned, and where it is necessary to have recourse to other appliances for its removal, such as the diving-bell or diving-helmet, and coffer-dams. The diving-bell has, in conjunction with dredging, been much used on the Clyde, and Mr Bald gives the following account of the operation as conducted on that river:— By diving-bell.

"Between Erskine Ferry and the New Shot Isle the bed of the Clyde, for a distance of 2000 yards, was greatly encumbered with stones and stone boulders, which were highly injurious to vessels if they grounded there; and frequently large ships, in being tugged through this part of the river-channel, had their copper bottoms injured when they touched the rocky channel-bed. In deepening and clearing this part of the river, two diving-bells were employed, and one, and sometimes two, steam-dredgers. The clearing and deepening of this channel was exceedingly severe on the machinery and working-gear of the steam-dredgers; the speed of the engines was therefore governed by the nature of the material in the bottom; and although the iron-work frequently gave way, yet spare links and buckets being always ready to replace those

[1] "Account of Blasting on the Severn," by George Edwards, C.E. (*Trans. of Institution of Civil Engineers*, vol. iv., p. 361).
[2] Clay weighs about 109 lb., and sandstone about 155 lb. per cubic foot.

Rivers. which broke, there was little interruption to the continuous working of the dredgers. When the dredgers had cleared away the material which covered the boulders in the bottom of the channel, the diving-bell boats were worked over the ground so cleared, removing all the larger boulders; and when that part of the channel had been cleared of them, the dredgers went again over the same bottom, removing all the lighter material from the heads of the lower boulders, preparatory to the bells commencing again; and these operations were continued until the necessary depth was attained.

"The buckets of the steam-dredgers, in working along the bottom, always slipped over the head of the large boulders, which the diving-bells alone could lift and remove. Some of these masses of trap or whinstone were 4 and 5 tons in weight, and from their rounded forms and smooth surfaces, it was evident that they had been brought from some distance. Some of them were of sandstone, but they were more angular than the trap boulders. Quantities of these boulders, lifted from the bed of the channel, might be seen lying along the sides of the river; and many of them had since been split and broken up by gunpowder for repairing the river dykes. The tops of some of the large stone boulders lifted from the bed of the channel were found grooved to a depth of about an inch or more, by the ship's keels having been rubbing over them; and metallic particles were distinctly to be seen upon their surface. In removing these stone boulders from the bed of the channel, the diving-bell men found numerous fragments of copper and iron which had been torn off the ship's bottoms and keels by the large stones; but latterly this had not been the case, as great progress had been made in the removal of the boulders, and the deepening of the channel."

Large isolated masses of stone have also been removed *en masse* from many rivers by fixing louises in them, and raising them by floatation. On the Tay this was done to some extent, and one boulder of 50 tons was raised from the river by that means. Where a large area and considerable depth of solid rock has to be removed, coffer-dams are doubtless the best means of executing the work; but the chief difficulty in employing dams in the narrow channels of rivers is the obstruction which they necessarily present to the passage of floods and also to shipping. It is therefore a matter of high importance to reduce their bulk to the smallest possible limits. With this view the writer[1] designed a coffer-dam for the works of the River Ribble, which consisted of two rows of iron rods, 3 feet apart, jumped into the rocky bottom, and supporting two linings of planking, the intermediate space being filled with clay, and the whole structure being stayed from the inside, so as to present no obstruction beyond the outer line of the dam. Three dams of this construction were formed in the Ribble; and by means of them, a bed of rock, 300 yards in length, and of a maximum depth of 13 feet 6 inches, was successfully excavated. The maximum depth of water at high-water against the dam was 16 feet, but in very high floods of the river the whole dam was sometimes completely submerged; but on the water subsiding, it was found that the iron rods, on which alone its stability depended, although only jumped 15 inches into the rock, were not drawn from their fixtures. As this construction of dam completely overcomes the difficulty of fixtures in a hard bottom, where piles cannot be driven, and offers very little obstruction to the navigation; and moreover, as it has been successfully used on a large scale, and seems to fulfil all the conditions demanded in such a situation, it may be perhaps considered generally applicable to situations where

Rivers. By coffer-dams.

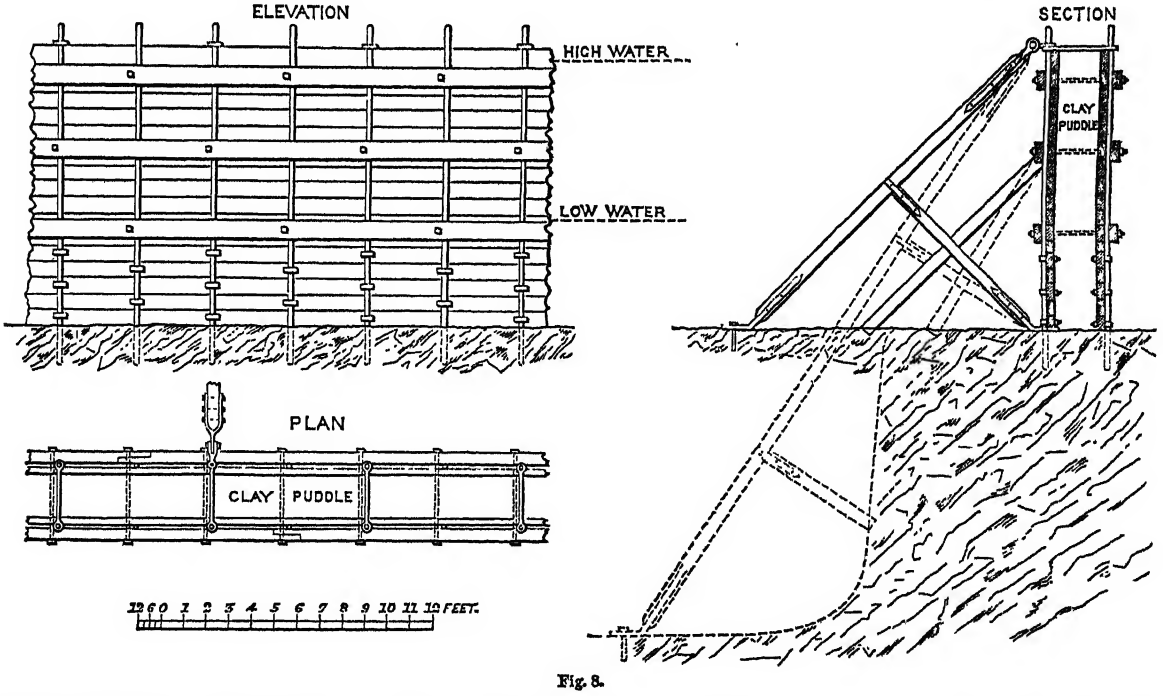

Fig. 8.

there is a hard bottom and limited space. The sketch (fig. 8) shows, by an elevation, section, and plan, the manner in which it was constructed.

5. *River-Walls.*

In open estuaries filled with sand-banks, the courses of rivers are liable to constant alteration, due to every change in the tides or winds. The accompanying woodcut (fig. 9) of the River Lune illustrates this remark; the several dotted lines represent the variation of the channel during the period of a few years. This tendency to wander is common to all rivers when left undirected to work their way through a

[1] "Description of a Coffer-Dam adapted to a Hard Bottom," by David Stevenson, C.E. (*Trans. of Inst. of Civil Engineers*, vol. iii., p. 377).

Rivers.

tract of sand; and the evils attending such a state of matters are generally of a serious nature, proceeding mainly from a constant abrasion or wasting of the sand-banks. This abrading action, operating during every flood and ebb tide, sets loose a large amount of floating sand, which is drifted to and fro, and deposited in some new situation. A channel

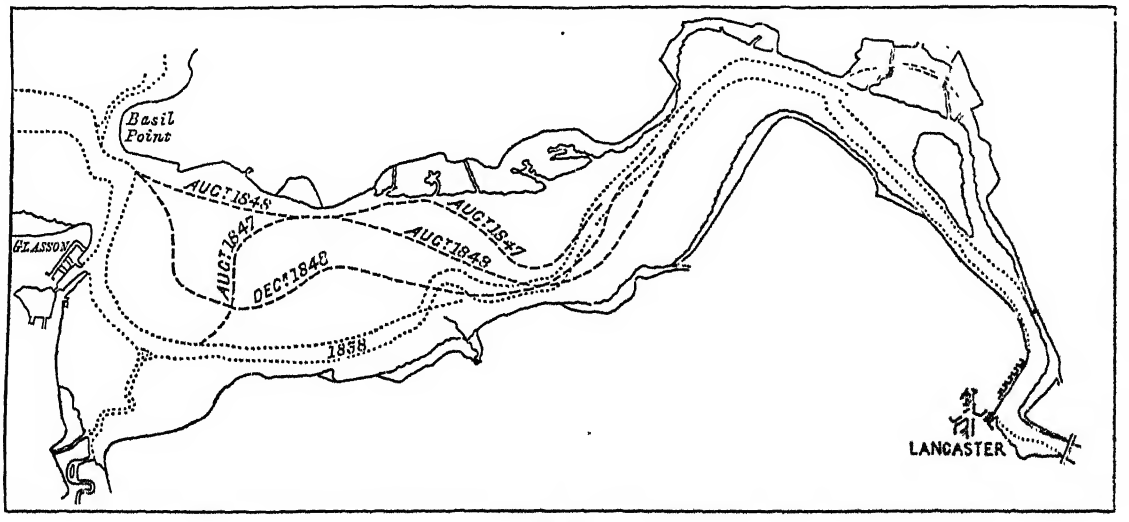

Fig. 9.

which is constantly shifting its course never remains sufficiently long in one position to form for itself a properly defined bed, but is in fact always in a transition state; the sand which is worn from the *concave* being thrown to the *convex* side of the stream, while some portion of the floating materials, carried to and fro during this process of perpetual change, is often deposited, and forms shoals in the middle of the fairway. A river left in this state of nature cannot possibly attain the *maximum* depth due to the natural scour of the tidal currents, as their power is expended in abrading and removing the sand-banks through which the stream flows, and not, as it ought to be, in deepening and scouring its bed. In such cases what is wanted is to secure a permanent channel, by guiding the first of the flood and the last of the ebb tide by means of walls, so that the strength of the currents may constantly operate on the *same line of channel*. In this way, it is obvious that not only will the advantage of a permanent navigable track be obtained, but the constant action of the currents of flood and ebb tide flowing in the same channel, will secure a much greater permanent depth than they could possibly do if permitted to wander at random through the estuary, sometimes operating in the same channel, and at other times directly opposed to each other.

Comparative advantages of straight and curved walls.

Questions have been raised as to the comparative advantages of straight and curved walls for directing a channel. It is believed that, in most cases, the direction of such walls is necessarily determined, not by any abstract consideration as to the superiority of straight or curved walls, but chiefly by the relative positions of the points between which the stream is to be conducted, and the outline and geological formation of the shores and banks of the estuary that intervene between those points. The consideration of such matters may render it expedient, according to the special circumstances of the locality, to adopt walls having *concave*, *straight*, or *convex* outlines, as shown in figs. 10, 11, and 12.

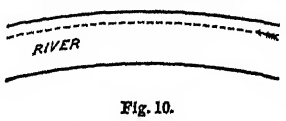

Fig. 10.

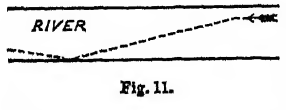

Fig. 11.

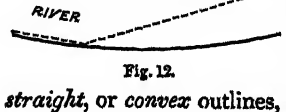

Fig. 12.

Viewed as a purely abstract question, it may, we think, be safely affirmed, that a stream is most likely to follow a permanent course when directed by a concave wall, as shown in fig. 10, in which the axis of the stream is represented by the dotted line. Dr Young observes that the centrifugal force in curved channels has a tendency to draw the greater portion of the water to the concave side, and thus the greatest scouring power, and consequently the greatest depth of the stream, will be found upon that side. In a channel directed by straight walls (fig. 11), the current has no such decided bias for either wall, and is consequently easily thrown across from side to side. A wall, on the other hand, having a convex outline, as shown in fig. 12, is (especially if the radius of curvature be small) still less suitable as a guide, as the line of wall diverges from the direction of the axis of the current. These remarks are not hypothetical, as the writer has found that their correctness has been verified by cases in actual practice. There is doubtless some disadvantage in the deep water being on one side of the channel, as more particularly shown in the cross section, fig. 13. It would be more convenient for navigation were the deep water in the centre; but it is found that the current invariably adheres to one or other of the walls, and it is better that the channel should keep constantly to one wall, than that it should alternate from side to side, as is more apt to be the case in absolutely straight channels.

Fig. 13.

The direction and extent of river-walls must, however, be carefully considered by the engineer with reference to existing circumstances, and every case must be judged *per se*. But we think it will be found safe, in executing such works, to adhere as closely as possible to the following general rules:—

First, The channel through open estuaries should, in all cases where funds will admit of it, be guided by double walls. In cases, however, where the estuary is bounded by a hard beach, presenting a favourable line of direction, a single wall may occasionally be found sufficient. All curves which it may be necessary to introduce should be of as large a radius as possible, and should, if practicable, be tangential to each other, or to the straight parts of the line with which they are connected.

Second, The walls should not be *raised* to a higher level above the low-water line than is absolutely necessary for the purpose of conducting the early and late currents of the

Rivers. tide; and their direction should be marked by occasional perches.

Fig. 14 represents the disposition of such walls in estuaries, as executed under the direction of Messrs Stevenson They are raised from 3 to 5 feet above the low-water line so that, while they guide the low-water channel, they do Rivers.

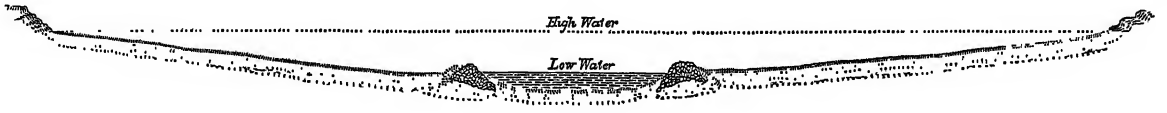

Fig. 14.

not prevent the tide at high-water from flowing on either side of them and filling the estuary.

Third, River-walls should, during their erection, be pushed forward with vigour, and not in a desultory, timid manner; the effect of such a course being to increase the depth of water in which the wall has to be made, and the amount of stone required for its construction.

Fourth, It will be found that such walls as we have been describing will be most advantageously formed of rough rubble stones, backed with clay and gravel, in the manner shown in fig. 15.

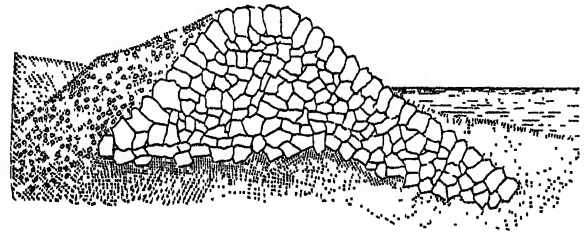

Fig. 15.

It was found by Mr Park, under whose immediate directions, as local engineer, the walls on the River Ribble, which are about 12 miles in length, were constructed, that their foundations, with few exceptions, did not sink more than a few feet below the sand. He found that it was advantageous to mix clay in the internal core of the wall; and after the materials were deposited, it was necessary from time to time, in certain places, to add additional stones to make up slips, before attempting to pitch the top or the face of the slope. Walls somewhat similar have also been largely introduced on the Clyde by Mr Walker.

6. *Scouring.*

The removal of hard portions of the bed of a river by dredging or coffer-dams, and the direction of the channel by low walls, are operations which are in themselves improvements; but they further operate beneficially in causing the currents to scour the softer parts of the river's bed, so that it sometimes happens that by dredging a few hundred yards of hard material from a river's bed, or erecting a short wall, thousands of tons of soft materials are scoured away by the action of the current. In all river improvements this is an effect which should be fully taken into consideration by the engineer, especially in forming estimates; and its importance will be apparent on inspecting the section of the River Lune (Plate II.) By dredging the upper shoals of that river, which are marked in hatched lines in the section, the whole lower part of the river was deepened by the natural scour, without entailing any expense in its removal. To facilitate this scour, a species of harrow has sometimes been applied, which is drawn to and fro by a tug-steamer across the bank to be removed. This system was extensively employed by Captain Denham in opening the Victoria Channel at the Mersey; it was also employed by Messrs Stevenson at the Tay; but it is obvious that it can only be advantageously used where there is deep water in the immediate neighbourhood of the bank to be removed, in which the sand and mud disturbed by the harrow, and carried off by the current, may be deposited. The process of scouring has, in some situations, to the knowledge of the writer, continued in operation for many years after the completion of the original work, the low-water level of the river continuing gradually to sink; and as this process goes on, it sometimes happens that hard portions of the bottom originally covered become gradually exposed.[1] Such obstructions are, in fact, hard portions of the bed brought to light, in consequence of the improvement of the river, and must not be mistaken for accumulations due to ill-regulated currents. It is necessary, however, that such hard portions should be removed as soon as they appear, otherwise they disturb the currents and occasion shoals. Whenever the depth due to the currents acting in their improved direction has been reached, such obstructions will cease to present themselves.[2]

The effect of works executed according to the principles indicated is,—*First*, to fix the navigable track in a defined course; *second*, to deepen the bed of the river; *third*, to reduce the slope, and lower the low-water level; and, *fourth*, to increase the duration of tidal influence and the quantity of tidal water in the river. The benefits to navigation are threefold:—*First*, greater depth of water; *second*, a properly defined channel; and, *third*, a greater length of time during which, in consequence of the presence of the tide, the river is navigable.

The writer has, before leaving this part of the subject, to state that the works specified are believed to be those most *generally* applicable. All of them may not be applicable in every case; and there may be special cases which render it expedient to adopt works of a somewhat different, and, in some respects, apparently antagonistic character,—such, for example, as the contraction of channels by means of quay-walls.

SECT. V.—APPLICATION OF THESE WORKS IN PRACTICE.

Application of these works in practice.

We come now to give a sketch of navigation improvements, executed in accordance with these general views, and to show their application in practice, and the effect produced by them. The first example to which we shall allude is the River Tay, improved under the advice and direction of Messrs Stevenson of Edinburgh; as we know of no instance in which the improvements effected by particular works are more fully and satisfactorily demonstrated by a comparison

[1] Mr Rendel, in his address as president of the Institution of Civil Engineers in 1852, says,—"At the present moment changes are taking place in the Thames and most of the principal rivers, which afford invaluable opportunity for observations on the effects rivers can produce by their own action, and also on what is done by the passage of steam-vessels in keeping the lighter silt constantly in motion."

[2] Admiral Beechey, in his *Observations on the Tides of the River Severn*, mentions a fact which it is proper to record. He says, "While upon the subject of the low-water line, it may here be remarked, that the inverse of the ordinary effect of the spring-tide occurs in the river above Lidney. From Lidney downwards to the sea, the low-water at springs follows the general rule of being lower at such times than at the neaps; but above Lidney the reverse takes place, the low-water at the springs being higher than at the neaps. This, no doubt, is occasioned by the tide at springs throwing more water into the river than can escape before the return of the following tide."

Rivers. of observations made *previously* and *subsequently* to their execution, than in the case of that navigation; where the changes were brought about in so short a time, and were so marked as to leave no doubt, even to superficial observers, of their attainment, and no difficulty, by the use of proper means, in ascertaining their amount.

River Tay. The River Tay, with its numerous tributaries, as stated in the table at the end of this treatise, receives the drainage-water of a district of Scotland amounting to 2283 square miles, as measured on Arrowsmith's Map. Its *mean* discharge has been ascertained to be 274,000 cubic feet, or 7645 tons of water per minute. It is navigable as far as Perth, which is 22 miles from Dundee, and 32 from the German Ocean. The different points on the river, hereafter to be referred to, will be seen in the small chart given in Plate II.; and we propose, in this particular case, to enter somewhat into detail as to the nature of the obstructions to the navigation, the means employed for their removal, and the effects produced by the works on the tidal currents; as the remarks made will, it is believed, serve to illustrate the subject of river improvement generally.

Before the commencement of the works, certain ridges, called "fords," stretched across the bed of the river at different points between Perth and Newburgh, and obstructed the passage to such a degree, that vessels drawing from 10 to 11 feet could not, during the highest tides, make their way up to Perth without great difficulty. The depth of water on these fords, the most objectionable of which were six in number, varied from 1 foot 9 inches to 2 feet 6 inches at low, and 11 feet 9 inches to 14 feet at high water of spring tides; so that the regulating navigable depth, under the most favourable circumstances, could not be reckoned at more than 11 feet. In addition to the shallowness of the water, many detached boulder stones lay scattered over the bottom. Numerous "fishing cairns," or collections of stones and gravel, had also been laid down, without regard to any object but the special one in which the salmon-fishers were interested, and in many cases they formed very prominent and dangerous obstructions to vessels. The chief disadvantages experienced by vessels in the unimproved state of the river was the risk of their being detained by grounding, or being otherwise obstructed at these defective places, so as to lose the tide at Perth,—a misfortune which, at times when the tides were falling from springs to neaps, often led to the necessity either of lightening the vessel, or of detaining her till the succeeding springs afforded sufficient depth for passing the fords. The great object aimed at, therefore, was to remove every cause of detention, and facilitate the propagation of the tidal wave in the upper part of the river, so that inward-bound vessels might take the first of the flood to enable them to reach Perth in one tide. Nor was it, indeed, less important to remove every obstacle that might prevent outward-bound vessels from reaching Newburgh, and the more open and deep parts of the navigation, before low-water of the tide with which they left Perth.

The works undertaken by the harbour commissioners of Perth for the purpose of remedying the evils alluded to, and which extended over six working seasons, may be briefly described as follows:—

1*st*. The fords, and many intermediate shallows, were deepened by steam-dredging; and the system of harrowing was employed in some of the softer banks in the lower part of the river. The large detached boulders and "fishing cairns," which obstructed the passage of vessels, were also removed.

2*d*. Three subsidiary channels, or offshoots from the main stream, at Sleepless, Darry, and Balhepburn islands, the positions of which will be seen on the plan, were shut up by embankments formed of the produce of the dredging, so as to confine the whole of the water to the navigable channel.

3*d*. In some places the banks on either side of the river beyond low-water mark, where much contracted, were excavated, in order to equalize the currents, by allowing sufficient space for the free passage of the water; and this was more especially done on the shores opposite Sleepless and Darry islands, where the shutting up of the secondary channels rendered it more necessary. Rivers.

The benefit to the navigation in consequence of the completion of these works has been of a twofold kind; for not only has the depth of water been materially increased by actual deepening of the water-way, and the removal of numerous obstructions from the bed of the river, but a clearer and freer passage has been made for the flow of the tide, which now begins to rise at Perth much sooner than before; and as the time of high-water is unaltered, the advantages of increased depth due to the presence of the tide is proportionally increased throughout the whole range of the navigation; or, in other words, the duration of tidal influence has been prolonged.

The depths at the shallowest places are now pretty nearly equalized, being 5 feet at low and 15 feet at high water, of ordinary spring tides, instead, as formerly, of 1 foot 9 inches at low and 11 feet at high water. Steamers of small draught of water can now therefore ply at *low-water*, and vessels drawing 14 feet can now come up to Perth in *one tide* with ease and safety.

In obtaining the requisite data, both as to the design and execution of these works, minute tidal observations were made at various times during a period of ten years, from 1833 to 1844 inclusive, throughout the River and Firth of Tay, at the following stations,—viz., Dundee, which is marked No. 1 on the plan, Plate II.; Balmerino, No. 2; Flisk Point, No. 3; Balmbreich Castle, No. 4; Newburgh, No. 5; Carpow, No. 6; Kinfauns, No. 7; and Perth tide harbour, No. 8. The general results deduced from these observations are given in the following tables, and show, by the favourable change which has been effected in the tidal phenomena of the estuary, that the works executed fully answered the intended end:—

1. *Propagation of Tidal Wave.*

The following table of elapsed times, between arrival of the tide-wave, or commencement of the tidal flow, at the following stations, during *spring* tides in 1833 and 1834, shows the rate of its propagation:—

	Time. h. m.	Distance in Miles.	Rate of Tide-Wave in Miles per Hour.
Dundee to Balmerino.....	0 16	5·00	18·75
Balmerino to Flisk Point.....	0 29	2·93	6·06
Flisk Point to Balmbreich.....	0 26	2·04	4·69
Balmbreich to Newburgh.....	0 53	3 42	3·86
Newburgh to Perth (tide harbour).....	2 30	8 56	3·42

The result of observations made in 1842, 1843, and 1844, on spring tides, give the same velocity, as above stated, between Dundee and Newburgh, and the following rates between Newburgh and Perth:—

	Time. h. m.	Distance in Miles.	Rate of Tide-Wave in Miles per Hour.
Newburgh to Carpow.....	0 25	1·33	3·17
Carpow to Kinfauns.....	0 55	4·92	5·36
Kinfauns to Perth (tide har.)..	0 20	2·32	6·93
Giving, as a mean for the whole distance from Newburgh to Perth in 1844...	1 40	8·56	5·13
Time from Newburgh to Perth in 1833..	2 30	8·56	3·42

Thus showing an increase in the velocity of the tide-wave in the upper part of the river, which was improved, of more than 1¾ mile per hour as the result of the improvements.

The difference of the time in *neap* tides between Newburgh and Perth in 1844, was 1 h. 53 m.

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2. *High-Water Level.*

The levels of the surface of high-water at different stations throughout the river have been found to be unchanged, and the following results refer to the years 1833 and 1844:—

From Flisk Point to Balmbreich there is a fall of	5 in.	Spring Tides.
... Balmbreich to Newburgh there is a rise of	7½ „	
... Newburgh to Perth (tide harbour) there is a rise of	18 „	
From Flisk to Balmbreich there is a fall of	2½ „	Neap Tides.
... Balmbreich to Newburgh there is a rise of	6 „	
... Newburgh to Perth (tide harbour) there is a rise of	12 „	

3. *Low-Water Level.*

Rise on the Surface of Low-water (Spring Tides) in 1833.

	Ft. in.	Distance in Miles.	Rate of Slope per Mile in Inches.	Rate of Tide in Miles per Hour.
Flisk to Balmbreich there was a rise of	0 4	2·04	1·95	4·69
Balmbreich to Newburgh, a rise of	2 8	3·42	9·35	3·86
Newburgh to Perth (tide harbour), a rise of	4 0	8·56	5·06	3·42

Rise on the Low-water of Spring Tides in 1844.

Newburgh to Carpow, there is a rise of	0 5	1·33	3 75	3·17
Carpow to Perth there is a rise of	1 7	7·23	2·63	...
Hence from Newburgh to Perth, 1844, the rise is	2 0	8·56	2·80	5·13

The result of the observations of 1844 thus gives a depression on the level of the low-water mark on the gauge of two feet at Perth tide harbour.

4. *Duration of Flood and Ebb.*

The results of observations in 1833 and 1844 at Newburgh show that the duration of flood and ebb tides at that place are unchanged. The times are as follows:—

	H. M.
Spring Tides flow	4 20
... ebb	7 20
Neap Tides flow	4 30
... ebb	6 45

At Perth in 1833:—

Spring Tides flowed	2 20
... ebbed	7 0
Neap Tides flowed	3 15
... ebbed	7 0

At Perth in 1844:—

Spring Tides flowed	3 10
... ebbed	7 0
Neap Tides flowed	3 10
... ebbed	7 0
Increase of duration of Flood in springs at Perth	0 50

It will be observed from these tables that important changes have taken place:—

First, The fall on the surface of the river from the tide basin at Perth to Newburgh in the year 1833 was 4 *feet*, but after the works were executed it was only 2 *feet*.

Second, In 1833 the passage of the tidal wave from Newburgh to Perth (8·56 miles) occupied 2 hours 30 minutes, being at the rate of 3·42 miles per hour; but it is now propagated between the same places in 1 hour 40 minutes, being at the rate of 5·13 miles per hour,—giving a *decrease* in the time of 50 minutes, and an *increase* in the speed of the first wave of flood of more than 1⅔ mile per hour, since the commencement of the works.

Third, The spring tides in 1833 at Perth flowed 2 hours 20 minutes, and ebbed 7 hours; but now the tide flows 3 hours 10 minutes, and ebbs 7 hours,—being an *increase* in the duration of flood of 50 minutes.

The works on the Forth, also executed under the direction of Messrs Stevenson, produced changes on the tidal phenomena, which, in connection with those described on the Tay, are interesting and instructive as regards the propagation of the tide, and therefore we shall briefly allude to them. The river between Stirling and Alloa is very circuitous, the distance by the navigation being 10½ miles, while in the direct line it measures only 5 miles. The navigation was found to be impeded by seven fords or shallows which occur between Alloa and Stirling, and are composed of boulder stones, varying from a few pounds to several tons in weight, embedded in clay.

River Forth.

It was determined, in the first instance, to remove two of these obstructions, viz., the "Town" and the "Abbey" fords, which lie nearest to Stirling, and having the smallest depth of water, form the greatest obstruction to the free

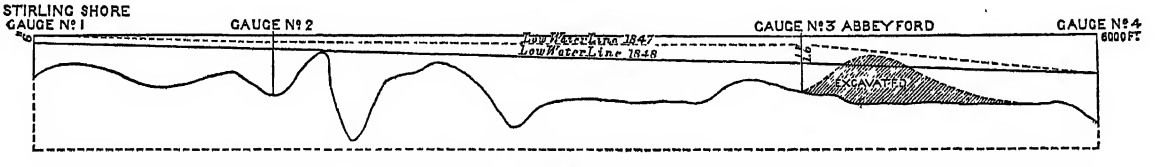

Fig. 16.

passage of vessels. The works were commenced at the lower end of the Abbey ford, and were carried regularly upwards. The new channel excavated through this ford was about 500 yards in length and 75 feet in breadth, and was deepened in some places about 3 feet 6 inches.

Previous to the commencement of the work, tide-gauges were erected in the positions marked 1, 2, 3, and 4, in fig. 16, on which a series of observations was made for the purpose of establishing the original tidal phenomena of the river. After the Abbey ford was cut through, farther observations were made on the same gauges; and it is to a comparison of these two sets of observations that we desire specially to refer. It is necessary to explain that gauge No. 1 is at Stirling quay, No. 2 about 500 yards farther down, No. 3 at the top of the Abbey ford, and No. 4 immediately below it. It will therefore be understood that the Abbey ford, through which a channel was cut, lies between gauges Nos. 3 and 4. The whole of the gauges were placed on the same level, so that their *readings* might be more easily compared; and the following are the results obtained with reference to the level of the low-water line:—

Levels of Low-water Line.	Gauge No. 4.	Gauge No. 3.	Gauge No. 2.	Gauge No. 1.
In 1847 the low-water line was found to stand at the following levels	Ft. in.	Ft. in.	Ft. in.	Ft. in.
	2 0	5 0	5 3	5 6
In 1840	2 0	3 6	4 6	5 0
Depression	0 0	1 6	0 9	0 6

From this tabular statement, we find that the low-water level at No. 4, which is below the site of the works, remains unaltered, but that it has fallen 1 foot 6 in. at the top of the Abbey ford (through which the cut has been made). It further appears that the formation of this cut has drained off the water, and lowered the surface 9 inches at gauge No. 2, and 6 inches at gauge No. 1, which is at Stirling. The

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former and present low-water lines and bed of the river are represented in fig. 16, in which is also shown the amount of excavation on the Abbey Ford by hatched lines. This general depression of the level has of course altered the slopes or inclinations formed by the surface of low-water; the slope between 4 and 3 being decreased, while the inclinations between 3 and 2, and between 2 and 1, have been increased in the following ratios:—

Inclinations.	Dist.	1847.	1848.	
	Feet.	Inches per Mile.	Inches per Mile.	Difference in 1848.
Inclination between 4 and 3.....	1550	122·5	61·3	−61·2
Do. do. 3 and 2.....	3050	5·19	20·77	+15·58
Do. do. 2 and 1.....	1400	11·31	22·62	+11·31

Again, these changes on the low-water line have produced corresponding alterations on the velocities of the first wave of flood, which are found to be as follows:—

Velocities.	1847.	1848.	Difference.
	Minutes.	Minutes.	Minutes.
Time occupied by first wave of tide in passing between gauges Nos. 4 and 3	24	8	−16
Do. do. Nos. 3 and 2...	6	11½	+ 5½
Do. do. Nos. 2 and 1...	6	8½	+ 2½
Do. do. Nos. 4 and 1...	36	28	− 8

From this it appears that between Nos. 4 and 3 there is an acceleration of 16 minutes, while between 3 and 1 there is a retardation of 8 minutes, leaving the difference, or 8 minutes, as the actual amount of acceleration at Stirling, due to the removal of the ford and the lowering of the low-water level 6 inches at that place. The rates of propagation in miles per hour are as follows:—

Rates of Propagation.	1847.	1848.	Difference.
	Miles per hour.	Miles per hour.	
Rates of propagation between Nos. 4 and 3.....	·65	2·2	+1·55
Do. do. Nos. 3 and 2...	5·77	3·0	−2·77
Do. do. Nos. 2 and 1...	2·65	1·87	−0·78

Relations of the slopes and rates of tidal propagation.

These observations and results seem to throw some additional light on the circumstances which modify the propagation of the tidal wave. The table of the results obtained at the Tay shows that the *de*creased inclination of the low-water lines of that river was attended by an *acceleration* of the velocity of the tidal wave; and the above observations further show that a *retardation* has attended an *in*creased inclination of the low-water line of the upper part of the Forth. From the foregoing tabular statements, it will be seen that between gauges 4 and 3, where the slope has been decreased, the propagation has been accelerated; while between 3 and 2, where, from the state of the works when the observations were made, it is found to have been increased, the rate of propagation had been sensibly retarded. It is worthy of remark, however, that the rates of propagation do not, either at the Tay or Forth, *bear any constant relation to the slopes*, but are modified by other circumstances; in proof of which, it will be found that the rate of propagation at the Forth between gauges 4 and 3, where the slope is 61·3 inches per mile, is actually greater than between gauges 2 and 1, where it is only 22·62 inches per mile. The circumstances of the Forth at this particular place are somewhat peculiar. Before the Abbey ford was cut through, it acted as a dam extending across the river, and had the effect of increasing the depth at low-water all the way up to Stirling. By cutting the channel through the ford, however, not only has the water been drained off and rendered shallow, but its surface has been broken by the projection of boulders from the bottom, which formerly were entirely covered; and while this effect has taken place in the upper part of the river, a comparatively smooth cut, with regular sides and bottom, has been formed in the Abbey ford, through which the river flows at low-water in a body of considerable depth. The writer therefore attributes the slow propagation of the tide between 2 and 1 to the shallowness of the water and the very rugged state of the bottom, which is in many places completely studded with boulders, rising some above the surface at low-water, and others to within a few inches of it; while the high velocity up the steep slope of the ford is to be attributed—1*st*, To the depth of water caused by the whole river being made to pass through a comparatively narrow channel; 2*d*, To the rectangular cross section of the cut; and 3*d*, To the smoothness of the sides and bottom. At the Firth of Dornoch, again, as already noticed, between the Quarry and Bonar Bridge, a distance of 1 mile, although the water is shallow and the bottom rough, it is not, on the whole, more so than between gauges 1 and 2 on the Forth; but at the Dornoch the slope on that mile is no less than 6 feet 6 inches, and the rate of propagation is only two-thirds of a mile per hour. Moreover, it was found that the tide did not begin to show at Bonar until it had risen 6 feet 6 inches on the gauge at the Quarry, being the exact difference of level between the two points of observation.

These various results as to slopes and rates of propagation, as well as others which have come under the writer's notice, seem to justify the following deductions as to the propagation of the tide-wave in rivers with sloping surfaces and irregular bottoms:—1*st*, That a decrease of slope is followed by an acceleration of the rate of propagation of the tidal wave. 2*d*, That an increase of slope is followed by a retardation of the rate of propagation. 3*d*, That the rate of propagation does not bear any constant relation to the amount of slope, although it is to some extent modified by it. 4*th*, That while the rate of propagation in rivers is in some measure due to the depth of water, it is nevertheless influenced by the slope of the surface, the form of the channel, and the obstructions protruding from the sides or bottom. 5*th*, That if not in all cases, at least when there are steep slopes and shallow water, as at the Dornoch Firth, the level of the crest of the wave must rise to the level of the surface of the water (or perhaps the bed of the river) above it, before a progressive motion takes place; and, 6*th*, That, from the difficulty of dealing with so many variable elements, it is impossible in most rivers to determine the ruling circumstances which can be held as regulating the rate of tidal propagation.

Clyde.

The Clyde affords a striking proof of the extent to which river improvements may be carried. So insignificant was the stream in its natural state, that Smeaton, in 1775, proposed to erect a dam with locks in the lower part of the river, and to convert it into a tidal canal. In 1775, however, Golburne surveyed the river, and although he found that as far down as Kilpatrick the depth of water was only 2 feet, he nevertheless recommended the construction of a series of jetties from either side, for the purpose of narrowing and deepening the stream; and this may be held as the commencement of the improvement of the River Clyde, which originally barely afforded depth of water for larger craft than flat boats, but which now, as our readers know, admits vessels of large draught up to Glasgow Bridge. The reader must be cautioned from supposing, however, that this result has been attained by means of the jetties which were erected under the advice of Golburne. It was soon discovered that the object could not be gained by such

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works. It was not until the ends of the jetties were connected by longitudinal walls, and until dredging-machines were extensively employed, that the Clyde improvements began to assume an importance commensurate with the vast commercial interests of the city of Glasgow and surrounding districts. The works on the Clyde have latterly been under the direction of Mr Walker, and have mainly consisted in forming longitudinal walls, dredging, and increasing the width of certain parts of the channel, which had in the early stage of the improvements been contracted to an injurious extent.

River Ribble.

The Ribble in Lancashire, the improvements of which were designed by Messrs Stevenson, presents an example of a great amount of additional depth having been obtained in a comparatively short space of time. That river, according to Mr Park, who conducted, as resident engineer, the greater part of the works, has a course of 82 miles, and drains 900 square miles of the counties of York and Lancaster. The formation of the bed in which it flows rendered the state of the tidal compartment previous to the improvements very defective. The bottom in the lower part of the river consists of loose sand; while that of the upper reach is alternately compact gravel and sandstone rock. About half a mile below Preston, in particular, it was found that a solid ridge of sandstone, extending to 300 yards in length, stretched quite across the channel. Its surface was from 3 to 5 feet higher than the general bed of the river both above and below it, and so prominent an obstruction did it form, that the higher parts of the rock were occasionally left dry during the long droughts of summer. The propagation of the tidal wave, and free flow of the currents, were checked on approaching it; while the power of the tidal and fresh-water scours was in a great measure neutralized and rendered almost unavailable in keeping open the upper and lower stretches of the navigation; so that its influence in obstructing the river resembled that of a great artificial weir stretching across the stream. In proof of this, it may be stated that the ordinary rise of spring tides at Lytham, which is 12 miles seaward of Preston, is about 19 feet,[1] and that of neap tides is 14 feet, while at Preston, prior to the operations, the rise of spring-tides did not exceed 6 feet, and neap tides of 13 or 14 feet rise at Lytham did not reach Preston at all. The removal of the rock which encumbered the bed, was naturally viewed as the most urgent and important work for effecting an improvement in the tidal phenomena and general depth of water. To this, therefore, the Navigation Company first directed its attention, and in the course of eighteen months, succeeded in excavating a channel through the solid rock 300 yards in length, and in some places 13 feet 6 inches in depth. This operation was successfully accomplished, at an expense not exceeding L.10,000, by means of a coffer-dam of the construction already shown in fig. 8. In addition to this work, about 480,000 tons of gravel and sand have been removed from the upper part of the river by dredging; and 9 miles of low rubble walling (formed, in so far as it was available for the purpose, of the rock excavated from the bed of the river) have been constructed in accordance with the sketch shown in fig. 15, for guiding the current in the lower channel.

The effect of the different works that have been executed has been to increase the tidal range at Preston about 5 feet, and to accelerate the propagation of the tidal wave nearly an hour; and vessels, to which the navigation may be said to have been previously closed, now come up to the quays of Preston with comparative ease and safety.

River Lune.

The works on the Lune in Lancashire were executed by Messrs Stevenson, under the direction of the Admiralty. They extended over a period of four years, and consisted in removing fords by dredging, shutting up subsidiary channels, and erecting river walls; the whole operation costing under L.10,000. The sketch of the Lune in fig. 9 shows the varying state of the channel in its original condition, which was regulated by means of a single rubble wall, as the funds did not admit of a double wall being erected. It was necessary also, from the configuration of the shores, that the channel should follow the convex side of the wall which should, if possible, be avoided, as some difficulty occurs in maintaining the channel always close to the wall, —a difficulty which can only be removed by the formation of a second wall; and we mention this as an example of the desirableness, as already stated, of forming double walls in all cases when the funds at disposal will admit of it. Fig. 17 represents the gradual depression of the tidal lines

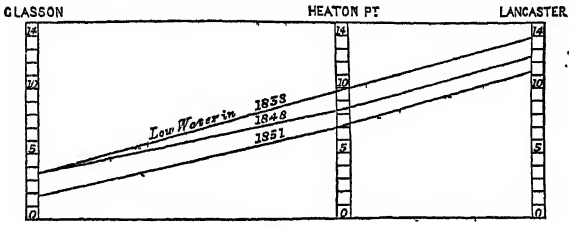

Fig. 17.

since the works commenced: the upper line shows the surface of the river in 1838, the intermediate line in 1848, and the lower line in 1851. The effect of the works has been to increase the depth of water up to the quays at Lancaster about 4 feet, and to prolong the duration of the tidal influence at that place thirty minutes in neap, and one hour and a half in spring tides; so that vessels can approach and leave Lancaster much earlier than formerly, while the improved channel is navigated with much greater ease.

It is unnecessary to give farther examples of navigations which have been benefited by means of works constructed on the principles which we have indicated. We doubt not that such cases could be quoted, although we do not possess sufficient details to enable us to do so; and we close this part of our subject by stating that the further extension of these works in such rivers as the Tay, the Ribble, or the Lune, and their application in many other cases, would be followed by a greatly increased improvement of their navigation.

Instances might be referred to where a course of treatment opposed to that which we have recommended has not been followed by similar favourable results; but we deem it sufficient to confine this treatise to an exposition of the correct principles of river improvement, without discussing erroneous practice or its baneful results; the more so as these have been most fully and ably treated by Mr E. K. Calver, R.N., whose investigations into the former and present state of some of our tidal rivers are of great value to the hydraulic engineer.[2]

SECT. VI.—SITUATIONS WHERE THE PRINCIPLES OF IMPROVEMENT RECOMMENDED ARE NOT APPLICABLE.

We have further to state, that in some situations the principles of improvement which we have advanced will be found to be of very limited application. Such cases indeed are rarely to be met with, but still it is necessary to notice them. We allude to rivers the tidal or intermediate compartments of which are, from natural causes, of very small extent. In illustration of what we mean, we may refer to

[1] Captain Sir Edward Belcher, while engaged in making the Admiralty survey of the Ribble, found that on one occasion the tide at Lytham rose 25 feet 7½ inches.

[2] *The Conservation and Improvement of Tidal Rivers*, by E. K. Calver, R.N., London, Weale, 1853.

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The Erne.

the Erne in Donegal, which has a tidal capacity of only 2¾ miles, extending from the bar up to the town of Ballyshannon, where the tidal flow is terminated by the "Salmon Leap," a perpendicular rise in the bed of the river of about 15 feet in height. This waterfall forms the limit of the tidal flow, beyond which it could not, without works of a gigantic character, be extended.

The Ness.

Another case is the Ness, which has a short course of about 2 miles, from a little above the town of Inverness to the Beauly Firth, at Kessock Roads. The difficulties attending the navigation of this river are mainly the prevailing outward currents due to the physical conformation of the bed of the Ness, which may be shortly described, as it illustrates generally a class of rivers which are very difficult to improve:—1*st*, The rise of ordinary spring tides at the mouth of the river is 14 feet. 2*d*, The distance to which the influence of such tides extends is only about 2 miles, which includes the whole tidal compartment of the river. 3*d*, The slope or inclination of the low-water line of this tidal compartment is no less than 7 feet per mile, and the tide takes from two to three hours to make its way up the first mile. 4*th*, The natural result of such a state of matters is, that no tidal current is generated at the mouth and propagated up the stream, and consequently the phenomenon of a current due to flood-tide may be said to be almost unknown.

Under these circumstances, the barrier to the free navigation of the River Ness is the absence of a tidal current or in-draught, to aid the entrance of vessels from Kessock Roads, and assist their progress up to the quays. This is at present effected by help of men and horses against the nearly constant downward current, which varies in strength with the amount of water discharged by the River Ness, during its frequent heavy floods.[1]

Back-water.

This absence of sufficient internal capacity and gentleness of inclination to admit of the generation of tidal currents is strikingly exemplified in the two rivers to which we have alluded, and naturally leads us to offer some general remarks in passing on the subject of the "backwater" and the "slopes" of rivers. In most, if not in all cases, it will be found (as more particularly noticed hereafter in section 8, in treating of bars) that it is of the highest importance to maintain unimpaired the full tidal capacity, and to be careful to make no reduction of its amount without obtaining an equivalent in the low-water section, to compensate for any reduction which it may be found advisable to make at or near the high-water line.

The subject of the reduction of backwater has given rise to various questions, which have occupied the attention of the engineer; but as every case must be judged on its own merits, and no two situations are exactly alike, it would be unprofitable to enter upon the discussion of the various arguments that have been adduced with reference to particular localities. All we can do is to lay down the general principle, that the more the tidal influence can be extended, and the larger the amount of backwater that can be obtained, the greater will be the benefit conferred on the navigation from the bar upwards; provided always that such increased scouring power is, by judicious works, placed under proper regulation. The question as to the possibility of excluding the tide from any part of an estuary, without injury to the outer channels, is a wide subject, as will be seen from our merely stating some of the considerations which may be held to determine the peculiar circumstances in which the exclusion of water may be compensated. These are, the configuration of the banks and bed of the estuary, the simultaneous levels of the surface of the water at different periods of the tide throughout the estuary, the velocities of the surface and under-currents at different periods of tide, and the times of ebbing and flowing, together with many other more minute data *peculiar to each case*, which it is not possible to specify in a general summary.

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Slopes of rivers.

The existence of a moderate amount of fall or slope on the low-water line of a river is a hopeful feature in its capabilities for improvement; while on the other hand, such a slope as that on the Ness proves a great barrier to its extended improvement as a tidal river; for it is obvious, that to obtain on that river a slope sufficiently gentle for easy navigation, it would be necessary to lower its bed to so great an extent, and to execute works of such magnitude, as to render it inexpedient to entertain such a project.

The consideration of the proper slope is important in river engineering. Dubuat considers 1 in 500,000 to be the smallest possible inclination that can be given to a canal to produce sensible motion. It will be found, on inspecting the table at the end of this treatise, that the slopes of tidal rivers vary from a few inches to several feet per mile.[2] As a general rule, we should say that the engineer may calculate on reducing the slopes of tidal navigations to 4 inches per mile = $\frac{1}{15840}$; and that they should not, if possible, exceed 10 inches per mile = $\frac{1}{6336}$.

Velocities of river currents.

Directly connected with the slope is the velocity of streams, —an important matter as affecting navigation, for it cannot be conducted with advantage in situations where the velocity of the currents is very great. The velocities of tidal currents in some places are very great; as, for example, in the Pentland Firth, where Captain Otter measured a velocity of 10·8 miles per hour, and in the Severn, where it was found to be 9 miles per hour. From 2 to 3 miles per hour is, however, a very common velocity on many of the rivers in this country, and it is found to present no inconvenience to the navigation of vessels. The following are the velocities of the currents in different rivers, with their authorities. The whole of them are surface velocities:—

Name.	Per Hour.	Authority.
	Mls. yds.	
Mississippi	5 0	Ellet.
Clyde, between Glasgow and junction of Cart, during ebb	0 1576	W. Bald.
Do., flood	0 771	Do.
Do., from junction of Cart to Dumbarton, ebb	1 1069	Do.
Do., flood	0 1561	Do.
Do. during high floods below Glasgow harbour, ebb	2 1613	Do.
Do. at narrow places during floods	3 1148	Do.
Severn, near Stonebench, flood, spring tide	4 250	Admiral Beechy.

Name.	Per Hour.	Authority.
	Mls.	
Severn, near Stonebench, ebb	3·12	Admiral Beechy.
Wear, spring tide, ebb	1½ to 2½	J. Murray, C.E.
Do., neap tides, „	1 to 1½	Do.
Do., flood tides	1 to 2	Do.
	Knots.	
Tay at Buddonness, sp. tides	2 to 2½	North Sea Pilot.
	Miles.	
Do. at Perth	3·09	Messrs Stevenson.
Willowgate at Perth	1·56	Do.
Dornoch Firth, Meikleferry, flood	2·63	Do.
Do. do. ebb	2·55	Do.
Tay at Mugdrum, flood and ebb	2 to 2½	Do.
Thames	2 to 2½	G. Rennie.

[1] See Report of Tidal Harbour Commission, by D. Stevenson, C.E., and Joseph Maynard, R.N., in *Admiralty Reports* for 9th March, 1847.

[2] The slope of the river Niagara at the rapids, immediately above the far-famed "Falls," is said to be 50 feet in half a mile, or 1 in 52·8.

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SECT. VII.—WORKS FOR ACCOMMODATION OF VESSELS.

The works we have described are for facilitating the ingress and egress of vessels. In addition to this, it is necessary to provide for their accommodation. For this purpose it is desirable, where local circumstances admit of it, that it should be possible to withdraw them from the action of the river currents which, during heavy floods accompanied by ice, are often very destructive to shipping.

Tide-basins.

This is accomplished in a simple manner by forming what are termed tide-basins, which are artificial cuts retiring from the stream having their sides bounded by quays or wharves, into which vessels may be withdrawn, but where they are still liable to take the ground at low-water. The object

Docks.

is accomplished more effectually by means of wet docks, for details of which the reader is referred to the article on that subject. In many situations, however, especially where the river is wide, and affords ample room, as in the case of the Foyle at Londonderry, for example, the berthage for vessels is afforded by means of lines of quays formed along the shore.

River quays or wharves.

Such quays constitute an important part of all harbours which are formed in tidal rivers; and in illustration of some of the various methods of construction adopted in such cases we submit the following cross sections. Fig. 18 shows the timber wharfage constructed by Mr Smith at Belfast,

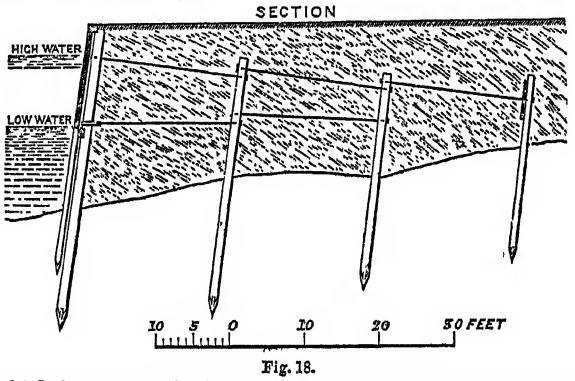
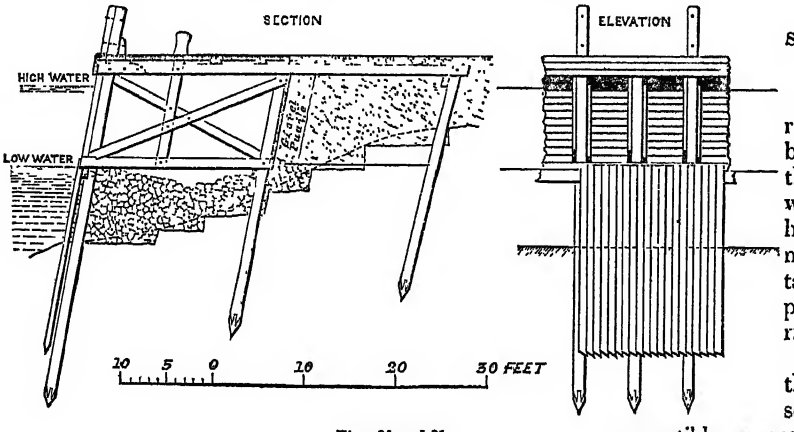


Fig. 18.

which is composed of a facing of timber-work secured by iron ties fixed to piles, the space behind the face-work being filled up, and the roadway formed at the top. Fig. 19 is

Fig. 19.

a plan showing the positions of the piles and ties. Sometimes a similar face-work is employed, backed by a wall of concrete; and iron plates have also been used for the facing,



Figs. 20 and 21.

instead of planking. Figs. 20 and 21 are a section and elevation of the quays of Londonderry, designed and executed by Messrs Stevenson. At this place the ground is very soft,

Rivers.

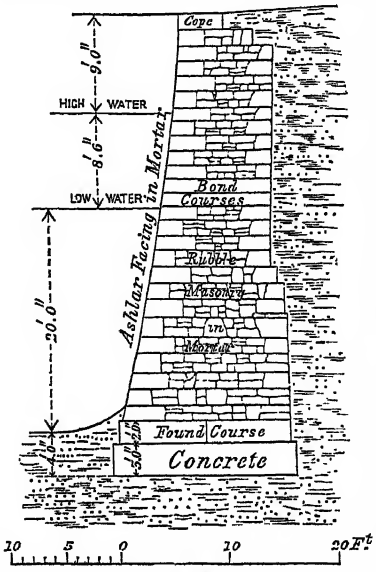


Fig 22.

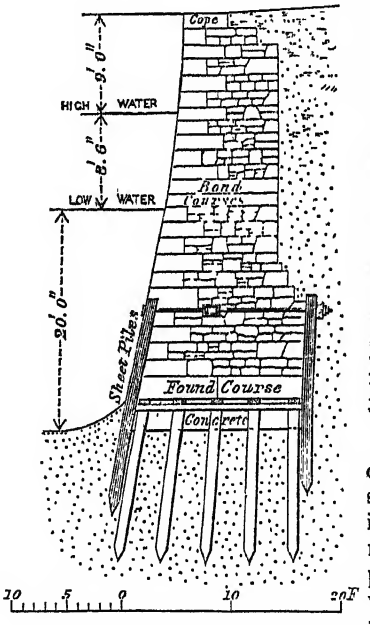


Fig. 23.

and in order as much as possible to reduce the weight, the front compartment of the wharf next the river is left open. Figs. 22 and 23, again, are sections of the stone wharves now being constructed from a design by Mr Walker, at Glasgow, under the superintendence of Mr Ure. Fig. 22 is the section adapted to a clay bottom; and fig. 23 is that which is adopted when the bottom consists of sand. In both cases the depth of water in front of the quays is 20 feet at low-water, and is intended to accommodate merchant vessels of the largest class. These examples furnish an illustration of the means employed for providing wharfage on tidal rivers; the details of their construction must be studied in treatises on such branches of engineering construction as Carpentry, Masonry, Piling, Foundations, Mortar, and Quay Walls.

Swing-bridges.

The engineer is often called on to construct swing-bridges in connection with navigations, but for particulars as to such works, reference is made to the article Iron Bridge.

SECT. VIII.—"SEA PROPER" DEPARTMENT OF RIVERS.

Having considered the treatment of rivers from their source to the ocean embracing the upper or "river proper," and the intermediate or "tidal compartment," we have now to direct attention to what we have termed the "sea proper" compartment, which, in the sense we have attached to it, may be said to embrace the phenomena connected with the flow of rivers or bodies of tidal water into the sea.

Bars.

In some instances, such, for example, as the Forth, the junction of the river with the sea occurs without giving rise to any very perceptible or marked phenomena; the one seems to glide naturally into and be mingled with the other, without producing any apparent disturbance of the currents or

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change on the bed of the channel. But such cases are exceptions; and, generally speaking, we may safely affirm that the junction of a river with the sea gives rise to what is termed a "bar,"—the most difficult subject with which the hydraulic engineer has to grapple, and the nature and cause of which we have now to discuss.

A bar, then, is the name applied to that shallow part of a channel which occurs at the junction of a river or estuary with the sea. On either side of it—that is, both seaward and landward of it—there may be ample depth of water for all purposes of navigation, but the bar forms the regulating navigable depth, and no passage over it can be obtained until the tide has risen sufficiently high to enable vessels to cross it. The depth at low-water on the bars of some of our rivers is as follows:—

The Mersey has a depth of from	9	to	10	feet at low-water.
„ Tyne	6	to	7	do.
„ Wear	3	to	4	do.
„ Ribble	7	to	8	do.
„ Tay	16	to	18	do.

And while these limited depths exist on the bar, there is in all of these cases ample depth within, or landward, for vessels of the largest class to lie afloat at all times of tide.

Theories to account for formation of bars.

Many theories have been propounded to account for the phenomenon of the bar. Some have advocated the idea that bars are composed of materials held in suspension by the river, and deposited so soon as its current is checked by meeting the still water of the ocean. But this theory, at all events as regards sea bars, of which we are now treating, is disproved by the facts of the Dornoch Firth, to which we have already alluded. The bar at that place occurs at a point 14 miles seaward of the point at which the river enters the sea. The idea that a bar of such magnitude as that at the Dornoch Firth, could be formed by the detritus brought down by the small rivers Oykell and Cassily, is wholly untenable, and is indeed contradicted by the fact that the bar and adjoining banks are composed of pure sand; and hence the writer attributed its formation, when he examined the firth in 1842, entirely to the action of the sea. We find that Mr Ellet, though founding his opinion on totally different premises, also comes to the conclusion that the bars of the Mississippi were not due to materials deposited by the outgoing stream. In explaining his views, he writes as follows:—"The velocity of the river is not destroyed, nor very sensibly diminished, at the bars. When the river was rising, but still far from being at full height, I measured the velocity of the current on the bar of the Passàla Loutre, and found it to vary, at different times and places, from 3 feet to 3½ feet per second, or from 2 miles to 2$\frac{1}{10}$th miles per hour. I measured it also repeatedly on the south-west bar, and found it there 3 feet per second, or about 2 miles per hour. But there are many parts of the river where the speed of the current does not exceed 2½ miles, or even 2 miles per hour, in times of flood, and where it is, notwithstanding, more than 100 feet deep. In fact, on testing the velocity of the south-west pass, 4 miles above the bar, and in 5 fathoms water, I found the current to be but 2 miles per hour,—precisely the same as it was under like circumstances of wind and tide on the bar. The current of the Mississippi sweeps over the bars at the mouths of the passes, and at periods of flood many miles out into the gulf, with a velocity almost undiminished by its contact with the waters of the gulf." He therefore concludes that there is in the Mississippi no retardation of the river's velocity on the bar to account for any deposit due to such a cause. Another theory attributes bars to the want of sufficient scouring power; but when we find bars existing at the mouths of such rivers as the Mississippi, we cannot attach much importance to such a suggestion. Another theory attributes the *absence* of a bar to "the presence of a nearly equal duration of the period of the ebb and flow in the lower reach of the river accompanied by an extremely gentle inclination of its surface at low water."[1] To refer again to the Dornoch Firth, we have an equal duration of the ebb and flow throughout the firth, and a surface practically level, and yet we have as perfect a specimen of a bar at the Gizzen Briggs, at the mouth of the firth, as can possibly be imagined. We cannot, therefore, in endeavouring to account for the existence of bars, or the exemption from them, accept the explanations to which we have alluded.

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The bars with which we have to do in this country may be said to be of two kinds; one class of bars is due to the hard formation of the bottom, which occurs in some situations; the other class is due to the action of certain elements, on the soft matters of which the bottom in other places is composed. Of the first class are such bars as that at Ballyshannon in Ireland, or at the entrance of Loch Fleet in Sutherlandshire, both of which the writer has had occasion professionally to examine. The bar at Loch Fleet, for example, is composed of boulder stones firmly imbedded in a mass of indurated gravel, and is obviously a continuation of a bed of similar formation which seems to traverse the coast at that place. The consequence is, that no scouring power can prove available in deepening the channel. Such bars being entirely due to the hardness of the bottom, are generally comparatively easily treated by the engineer, and an encouraging prospect is held out that their removal will be attended with permanent benefit, since, by excavating a channel through them, the engineer at the same time removes the evil and its cause.

In the other class are comprehended those sand-bars which occur at the mouths of the firths of Dornoch and Tay, and of the Tyne, Wear, Mersey, Ribble, and other tidal rivers and estuaries; and it is to the formation of these capricious and troublesome accumulations that the theories to which we have alluded apply. The true source of all such bars is to be found, as already stated, in the action of the sea. The natural effect of the sea is to throw up sand, and form a continuous line of beach across the mouths of all our tidal rivers and inlets; while, again, the flow of the tidal and fresh-water currents tends to maintain an open channel through the beach. In this way the antagonistic action of the waves of the sea on the one hand, and the currents of the estuary or river on the other, produce the well-known feature of a submerged beach or sand-bank, extending from shore to shore across our inlets, having a deeper channel through them, which channel is termed the "bar." This explanation is due to the Abbot Castelli, who, in his work on the Mensuration of Running Waters, written in the beginning of the seventeenth century, gives the following clear announcement of his views:[2]—"As to the other point of the great stoppage of ports, I hold that all proceedeth from the violence of the sea, which being sometimes disturbed by winds, especially at the time of the waters flowing, doth continually raise from its bottom immense heaps of sand, carrying them by the tide and force of the waves into the lake; it not having on its part any strength of current that may raise and carry them away, they sink to the bottom, and so choke up the ports. And that this effect happeneth in this manner, we have most frequent experience thereof along the sea-coasts; and I have observed in Tuscany, on the Roman shores, and in the kingdom of Naples, that when a river falleth into the sea, there is always seen in the sea itself, at the place of the river's outlet, the resemblance as

[1] *Treatise on the Improvement of the Navigation of Rivers*, by W. A. Brooks.

[2] *The Mensuration of Running Waters*, by Don Benedetto Castelli, Abbot of St Benedetto Aloysio, and professor of the mathematics to Pope Urban VIII. in Rome; translated by Thomas Salusbury, Esq., London, 1661.

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it were, of a half-moon, or a great shelf of settled sand under water, much higher than the rest of the shore, and it is called in Tuscany *il cavallo*, and here, in Venice, *lo seanto;* the which cometh to be cut by the current of the river, one while on the right side, another while on the left, and sometimes in the midst, according as the wind fits. And a like effect I have observed in certain little rillets of water along the Lake of Bolsena, with no other difference save that of small and great.

"Now whoso well considereth this effect, plainly seeth that it proceeds from no other than from the contrariety of the stream of the river to the impetus of the sea-waves; seeing that great abundance of sand, which the sea continually throws upon the shore, cometh to be driven into the sea by the stream of the river, and in that place where these two impediments meet with equal force, the sand settleth under water, and thereupon is made that same shelf or *cavallo;* the which, if the river carry water, and that any considerable store of it shall be thereby cut and broken, one while in one place, and the other while in another, as hath been said, according as the wind blows; and through that channel it is that vessels fall down into the sea, and again make to the river, as into a port. But if the water of the river shall not be continual, or shall be weak, in that case the force of the sea wind shall drive such a quantity of sand into the mouth of the port and of the river as shall wholly choke it up. And hereupon there are seen along the sea-side very many lakes and meers which at certain times of the year abound with waters, and the lakes bear down that inclosure, and run into the sea.

"Now it is necessary to make the like reflections on our ports of Venice, Malamocco, Bandolo, and Chiozza, which in a certain sense are no other than creeks, mouths, and openings of the shore that parts the lake from the main sea; and therefore I hold that if the waters in the lake were plentiful, they would have strength to scour the mouths of the ports thoroughly and with great force; but the water in the lake failing, the sea will, without any opposal, bring such a drift of sand into the ports, that if it doth not wholly choke them up, it shall render them at least unprofitable and impassible for barks and great vessels."

Conditions under which bars are formed.

The conditions under which such accumulations are formed the writer holds to be,—1*st*, The presence of sand or shingle, or other easily moved material; 2*d*, Water of a depth so limited as to admit of the waves during storms acting on the bottom; and 3*d*, Such an exposure as shall allow of waves being generated of sufficient size to operate on the submerged materials.

In confirmation of this opinion, we may once more refer to the Dornoch Firth. The Oykell joins it at a point about a mile below Bonar Bridge, but we find no indication of what may be termed a bar throughout the whole of the sheltered part of the firth, which extends for 12 miles seaward of that point, until we reach the outer portion which is exposed to the unbroken sea of the Moray Firth, and there we find an extensive sand-bank, forming as it were, a continuation of the shore on either side, and stretching quite across the mouth of the firth, with the bar in the centre of it. But the fact, that in all such bar-rivers and estuaries the depth is often found to be seriously diminished after heavy seas, is beyond doubt, and serves as a further confirmation of the correctness of the theory for which we are contending.

The same reasoning may explain why, in such a case as the Firth of Forth, for example, no bar exists. The Firth of Forth is an inlet or arm of the sea, of great width and depth, the seas entering it do not act on the bottom, so as to cause a heaping up of the material of which it is composed, in the same manner as in a shallow sea. This great natural depth continues as the Forth gradually contracts; and before the necessary conditions for the formation of a bar occur—namely, sufficiently shallow water and presence of sand—the sea is so land-locked that waves of sufficient size to produce the necessary effect cannot be generated. There is, in fact, in the Forth that gradual diminution of depth, and increase of shelter, which combine to produce the phenomenon of a river without a bar.

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We must also notice a cause for the formation of bars advanced by Mr Ellet. Although it is not applicable to the rivers in this country, still, from the observations he has made, we think it likely that his theory may be held to account for the bar of the Mississippi. It is founded on the fact, that at the junction of a river with the sea the fresh water flows in a stratum above, and distinct from, the salt water, for some distance after entering the ocean. This is occasioned by the higher specific gravity of salt water, the weight of fresh water being 1000, while that of salt is 1026.

Relative specific gravities of salt and fresh water.

Before noticing Mr Ellet's theory, however, we may state, that so far as we are aware, the first observations made on this subject were those instituted by the late Mr Robert Stevenson, of Edinburgh, on the River Dee in Aberdeenshire, in the summer of the year 1812, while engaged in surveying that river with reference to a disputed right of salmon-fishing. Mr Stevenson, in his report on that subject, states that, by means of an instrument devised for that purpose, he ascertained that the salt or tidal water of the ocean flowed up the channel of the River Dee, and also up Footdee and Torryburn, in a distinct stratum, next to the bottom and under the fresh water of the river, which, owing to the specific gravity being less, floated upon it, continuing perfectly fresh, and flowing in its usual course towards the sea, the only change discoverable being in its level, which was raised by the salt water forcing its way under it. The tidal water so forced up continued salt; and when the specific gravities of specimens from the bottom were tried, they were found to possess the greater degree of specific gravity due to salt water, while the surface specimens were found to be specifically unaltered.

Experiments at the Dee.

Similar observations have been made by the writer of this article in several places, with the same results. The appearance of fresh water floating on the surface of the sea is no doubt familiar to most persons. It occurs at the mouths of many of our rivers, and is most apparent when they are in flood, from the brown tinge given to the water, which is easily discoverable for many miles at sea. It is well known on our coasts to the crews of the welled smacks employed in cod-fishing, who invariably lose a great portion of their live stock if they happen to encounter what they term "a fresh," which is believed by them to be a brackish portion of the sea, caused by the imperfect admixture of fresh water discharged from rivers in flood. On this subject the following passage from the work[1] of Father Manuel Rodriguez, a Spanish Jesuit, is interesting, and its correctness, as regards the extent to which the influence of large rivers is felt, has since been corroborated by the investigations of Colonel Sabine.[2] "This river," says Rodriguez, speaking of the Amazon, "is like a tree; its roots enter as far into the sea as into the land. It communicates to it a flavour, so that at 80 leagues within the sea its waters are seen, and taste sweet, and in a semicircle of 100 leagues in circumference they form a gulf not the least degree brackish, so that sailors call it the fresh sea."

But to return to the Mississippi: Mr Ellet, in the following extract, says:—"The river water does not mix suddenly

[1] *El Maranam y Amazonas*, Madrid, 1684, p. 18.

[2] *An Account of Experiments to determine the Figure of the Earth, as well as on various other subjects of Philosophical Engineering*, by Edward Sabine, London, 1835, p. 445.

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with the sea, but rises upon it, floats over it, and rushes far out into the gulf on the top of the dense sea water, by which it is buoyed up. I tested this repeatedly, and found uniformly a column of fresh water, nearly 7 feet deep, in the gulf, entirely outside of the land, and salt water at a depth of 8 feet from the surface, and extending thence to the bottom. The river does not come down with a certain normal depth and speed, and encounter the gulf at the bar. No such process takes place. There is no sudden destruction of velocity, or consequent deposit of suspended silt. But the water of the Mississippi does not move over the surface of the gulf at a speed of 3 feet per second without imparting a portion of its motion to the sea.[1] The fresh water and the salt water take the same direction towards the sea, and with nearly the same velocity, but yet keep separate. This state of things clearly cannot exist at the bottom; for as the river water is for ever coming forward, if the salt water all flowed towards the gulf, it would all be carried out, and river water would take its place. Salt water must come in from some quarter, to supply the current of sea water that is for ever setting towards the gulf, beneath the water discharged by the river. This salt water can only come from the sea, and can only come in along the bottom. It is, in fact, an eddy that is here at work, the movements being in a vertical instead of a horizontal plane. Now, the question is, How does this account for the existence of the bar? The fresh water running out cannot produce deposit, for it has velocity enough to sweep away a foundation of coarse gravel. The outpouring salt water, immediately beneath the fresh, cannot produce deposit, because it also has a velocity seaward strong enough to remove anything that is brought down the Mississippi. The salt water that is coming in might produce, and I doubt not does produce, a deposit, for it passes over the soft muddy bottom of the gulf, and moves into the river, and along the bar, at a very slow rate. According to these facts, and this reasoning, there must be usually on the bar three distinct strata: 1*st*, Fresh water, running out at top, found by experiment on the S.W. bar to have a velocity of 3 feet per second. 2*d*, Salt water below the fresh, also running out with nearly the same velocity as at top; and 3*d*, Salt water coming in slowly along the bottom, and apparently a sheet of salt water between that running out and that coming in, which will be without motion.

"But as already said, and as is obvious, all the sea water that comes in must go out again. It comes in along the bottom, and it must go out between the column of salt water coming in and that of the fresh water going out. Each particle of salt water, therefore, must change its direction and position in elevation. It must pass from an inward-bound lower stratum to an outward-bound upper stratum. But in passing through this change of motion, its velocity up stream must be neutralized. It passes, to use a technical term, the *dead point*. At this point it may cease to bear its whole burden of mud, which it has brought from the gulf further forward. It leaves it, or a portion of it, at the turning-point. This turning-point is the place where the bar for the time being is in process of formation. But as the upper and lower strata are moving in opposite directions, the intermediate column must of necessity have a rotatory motion; that motion must be shared by the lower column of salt water, and this turning-point must therefore be found at the same time at different places along the bar."

Mr Ellet gives an interesting detail of his experiments on the saltness and freshness of the water, as taken from different depths, and also of the means he took to ascertain the strength and directions of the two under-currents referred to in his ingenious theory of the formation of the bar; but the details are too long to give in this sketch of his researches.

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We have seen that bars, in some situations, are formed by the hard strata of which the bottom is composed; that in other places they are due to the waves of the sea; and that in the case of the Mississippi Mr Ellet attributes the phenomenon entirely to the eddy caused by an under-current inwards.

The removal of *hard bars* is, as already noticed, likely in most cases to result in a successful issue; but the treatment of those bars which are due to the waves of the sea, with which class of phenomena we have chiefly to do in this country, is an operation not only more difficult to deal with, but far more uncertain in its results.

Depth of water due to amount of back-water.

From what has been said, the reader will see that we believe the depth of water, on such bars as are caused by the waves of the sea, to be in some degree proportional to the scour produced by the tidal currents, which cross them four times in every twenty-four hours. If this assumption be correct, it is obvious that the principle which should guide us in all our considerations as to increasing, or even maintaining the depth upon sea-bars, is the preservation of a sufficient amount of tidal water to counteract the tendency of the sea to heap up detritus at the mouths of our harbours. These two agents, the *waves* and the *tidal scour*, are constantly opposed the one to the other: a storm from the sea, or a heavy flood from the land, occasionally causes the one or the other to have the ascendancy; but this is only temporary. A variation in the depth of water on the bars of our harbours, caused by such temporary disturbances, may occasionally occur; but nevertheless, unless some work of magnitude is formed, so as to alter permanently the natural disposition of matters, no pilot has any difficulty in fairly estimating what is the general navigable depth over the bar of any of our seaports.

Comparison of amount of river and tidal water in firths and estuaries.

That the beds of the upper parts of rivers are scoured, and their depth maintained by the flow of the fresh-water stream, is not to be questioned; and it is also beyond doubt, that in many situations the upper portions of the tidal compartments of rivers are kept open in a great measure by the fresh-water stream; but it is no less certain that the opinions which would assign the depth of water in the lower parts of tidal rivers, and also through estuaries and across bars, to any other cause than the action of tidal water as the chief agent, are erroneous. We think this will be apparent by a reference to some of the investigations which have from time to time been made to ascertain the amount of the river or fresh water, as compared to the volume of the tidal water of some of our firths and estuaries.

Cromarty Firth and River Conon.

By means of a series of careful observations and measurements made at the Cromarty Firth in 1837, to which reference has already been made, Mr Alan Stevenson found that the River Conon, when highly flooded (a state of matters which of course occurs only occasionally), discharges during twelve hours a quantity which is only equal to $\frac{1}{37}$th part of the water which passes out of the firth at every ordinary spring tide, and $\frac{1}{19}$th of that which passes out at neap tides. While in its summer-water state, the produce of the river is reduced to $\frac{1}{1611}$ of the discharge of the firth in spring, and $\frac{1}{731}$ of the discharge in neap tides; a quantity too small to affect appreciably either the velocity of the currents of the firth or their scouring power. It has often been argued, that in situations where the velocity of the ebb exceeds that of the flood tide, the excess is due to the increased quantity of water passing out with the ebb, the volume of the ebbing waters being assumed to be augmented by the amount discharged by the river. But this

[1] This is in harmony with Venturi's well-known experiments, from which he found, that a body of water in motion leads or drags with it the particles of water at rest with which it may be in contact.

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is wholly disproved in the case of the Cromarty Firth; for while the increased quantity due to the river is seen to be only from $\frac{1}{781}$ to $\frac{1}{1641}$, the average velocity at the flood-tide at that place was found to be 2·9 miles per hour, while that of the ebb was 3·6; an increase which is in all probability due to the tide beyond the Suters falling more rapidly than it rises, and thus producing a greater head and more rapid current on the ebb, but is assuredly not due to any augmentation of water from the discharge of the Conon.

The Tay.

The Tay presents another example of the disproportion between the tidal and river waters. That river, as gauged by Mr Leslie when in flood, was found, including the Earn, to discharge 969,340 cubic feet per minute. Mr Walker, in his report to the trustees of Dundee harbour, assumes the discharge in round numbers at one million cubic feet per minute, or 240,000,000 during four hours, and arrives at the following conclusion:—"To compare the above with the effect of the tidal water at Dundee, I assume 15,000 acres as the average area (above Dundee) of the reservoir or estuary during the first four hours of the ebbing tide, and the vertical fall of tide during these four hours to be 11 feet. This will give 7,187,400,000 cubic feet, or thirty times the 240 millions of river water. To compare the effect upon the *bar*, the area of the river between Dundee and the bar must be added; and the tidal water upon the bar will then be upwards of *forty times* the river water."

Works recommended favourable for bars.

It will be apparent that an important question is suggested as to the manner in which such works as we have recommended for improving the upper parts of rivers may operate in assisting or retarding the scour of the bar. We have no hesitation in replying, that if executed in the manner we have indicated, they will improve the higher part of the river without prejudicially affecting the bar, and in certain cases they will operate beneficially on the bar also.

Piers for entrance to rivers.

The construction of piers for improving the entrances of rivers, as in the case, for example, of the Wear at Sunderland, is more properly included in the subject of harbours. Such works seem to us to act beneficially, not so much by increasing the *depth* on the bar, as by limiting the extent of shoal water at the entrance to the river. In its natural state such a river as the Wear flows across the beach from high to low water in a broad and shallow channel, the direction of which is ever changing. It thus forms a long bar or shoal, with broken water throughout its whole extent. But the projection of piers across the beach affords shelter from the waves, and admits of a navigable channel being excavated and maintained; and after a vessel crosses the short bar, which occurs at or near the pierheads, she not only gets into deeper water, but has the additional advantage arising from the shelter afforded by the piers. To this extent piers in such situations are highly advantageous. They further act beneficially in directing the flow of the tidal currents in a fixed channel across the beach and bar, and, in connection with an increase of tidal capacity in the interior, such as we have mentioned as the result of the works on some rivers, they cannot fail, if judiciously designed, to operate beneficially by maintaining an increased depth of water on the bar.

Groynes.

In certain situations where the coasts are faced with gravel or shingle beaches, accumulations or bars may be lessened by means of groynes, so formed as to intercept the gravel, and either retain it, or lead it past the harbour's mouth into an adjoining bay. The writer has in several situations recommended the adoption of such works; and Mr Walker has applied them with success at the harbour of Newhaven in Kent, where, in conjunction with increased backwater, due to deepening and removal of obstructions, the depth on the bar has been materially increased.

Schemes for gaining land and improving navigation not generally compatible.

Such twofold schemes as have for their ostensible object the improvement of rivers and the *formation of land*, have generally been unsuccessful in benefiting navigation. We do not affirm that river-works, constructed on the principle which we have advocated, have not the effect of *making land*, in the particular sense in which we shall afterwards explain it; but we do state that *land-making* is no part of sound *river engineering*. Judiciously designed works may, as we shall presently explain, have the effect of reclaiming and protecting land, while at the same time they, as their primary object, benefit navigation; but we know of no case where the interests of navigation have been promoted by any measure which has for its object the conversion of large tracts of tide-covered sands into cultivated fields.

River Dee.

We refer to the Dee in Cheshire, as an aggravated instance of the incompatibility of the two interests.[1] The outline of this river is shown in Plate I., from a survey by Messrs Stevenson, made in 1838. The River Dee Company, incorporated by act of Parliament in 1732, have from time to time reclaimed from the upper part of the estuary a large tract of land, extending to about 4000 acres, which is now in full cultivation; and alongside of this gradually gained territory the river has been conducted from Chester to near Flint, in a narrow canal of about 8 miles in length, and 400 feet in width. A considerable portion of land has also been reclaimed on the Flintshire side of the estuary, though not by the proprietors of the Dee Company; and it is believed that the aggregate amount which has from first to last been gained from the sea is about 7000 acres. Now it is well authenticated, that previous to the commencement of the land-making operations on that river, there was a depth of not less than a fathom at low water of spring tides up as far as Burtonhead, and that there was an anchorage for vessels of the largest size opposite to Parkgate, the positions of which places are marked on the plan. But when the writer surveyed the Dee in 1838, the depth of 6 feet was not found for more than 6 miles below Burtonhead, the low-water features of the estuary having been forced to that extent further seawards by the extensive reclamation of land in the upper part of the estuary, and the consequent diminution of the tidal scour. It cannot, we think, be disputed, that the effect of the works executed on the River Dee, whatever may have been the anticipations of their projectors, has been to shut out the sea, and form land at the expense of the navigation. They are designed, in fact, in direct opposition to the general principle laid down in the present treatise, which provides for the admission of the greatest possible quantity of tidal water.

Increase of tidal water produced by works on the Tay and Lune.

It seems also equally clear that an increase of tidal water must inevitably attend the execution of such works as we have proposed; but in proof of this assumption, and in contrast to the case of the Dee, it may be well for the reader's information to cite examples which have occurred in practice. Proceeding on actual calculations of comparative sections of the River Tay before and after the operations, the writer found that by the lowering of the low-water line, consequent on the improved state of the river, an additional quantity of sea water, amounting on an average to not less than 1,000,000 cubic yards, or 760,560 tons, is *during every tide* propelled into and again withdrawn from that part of the river which lies above Newburgh. This quantity is equal to two hours' discharge of the Tay in its ordinary state; and it therefore follows that the additional tidal discharge for one year is equal to two months' constant ordinary flow of the River Tay. In the same way it was found by

[1] *Great Britain Coasting Pilot*, by Captain Greenville Collins, hydrographer in ordinary to the King's most excellent Majesty, London, 1767; *Reports to the Admiralty*, by Captain Washington; *Report of Tidal Harbour Commissioners*; *Report* by Messrs Stevenson, 1839.

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calculation that the additional amount of tidal water admitted every tide into the Lune above Heaton, in consequence of the operations, was 736,278 cubic yards.[1] To estimate truly the beneficial effects of these important changes on the scouring power of the Tay and the Lune, it must be kept in view, that in both cases the increased volume of tidal water, being obtained by the enlargement of the *low-water channel*, operates during *every tide*, and thus may be held to produce the *maximum* amount of benefit; for it is obvious that a cubic yard of low-water area, gained in the low-water channel, and filled by every tide, is very much more valuable than a similar amount of space gained at or near high-water of spring tides, which is filled only at remote intervals.

Depression of low-water line apt to mislead.

The tendency, then, of the whole system of works recommended in this treatise is to lower the low-water line, and to admit an increased amount of tidal water to act on the low-water channel. But the depression of the low-water line, particularly when the river is confined by walls in the lower part of an estuary, conveys the impression that a great rise has taken place in the level of the adjoining sand-banks, and it has consequently been thought that the erection of river walls is inconsistent with the principles of non-exclusion of tide-water which we have recommended; but we are enabled to show that this is not the case. In its natural state, the channel of such an estuary as the Lune or the Ribble, as already explained in section iv., is subject to constant change of position. The writer has seen many acres of marsh or grass land in such estuaries carried off by the waves, and the solid matter of which they were composed scattered over the shores and sand-banks. Now, the effect of fixing the channel by means of walls, in the manner which has been recommended, is to form one permanent navigable track; and the banks on either side, being no longer subject to the periodical inroads of the river or tides, gradually rise in elevation until they are capable of producing vegetation, and ultimately become what are termed marsh lands. When a river channel has been thus fixed and confined by walls, it has been ascertained by repeated observation that the tidal water comes up the channel in a comparatively pure state, instead of being loaded with particles abraded from the sand-banks and marshes. It has also been found that the process of deposit at the sides of an estuary so improved goes on very slowly after it has reached a certain stage; for the materials deposited on the upper parts of the banks are, as afterwards more particularly described, exceedingly fine, and are carried only by the highest tides, which seldom reach those elevated portions of the shores. From all these considerations we infer that the effect of river-walls upon an estuary is to prevent the constant disturbance of the materials of which the banks are composed, but not to occasion additional accumulations.

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As tested in the Lune.

The writer had an opportunity, in the case of the Lune, of testing by actual measurement in how far the raising of the banks, caused by the erection of walls, was due merely to a new disposition of the materials which originally filled the bed of the estuary, or to additional foreign matters deposited in consequence of the operations; and the following results are instructive, being, it is believed, the only observations that have been made to determine the state of the sand-banks of an estuary after the river has been improved, as compared with their former condition.

The rubble walls and other works constructed on the Lune caused, as might have been expected, a very considerable alteration in the position and form of the sand-banks in the estuary; and this alteration, in connection with the depression of from 2 to 3 feet in the low-water level of the river, was apt to lead a casual observer to suppose that a great accumulation of sand had taken place, and consequently that a corresponding amount of back-water had been excluded. The writer was authorized by the Admiralty to make such observations as were neces-

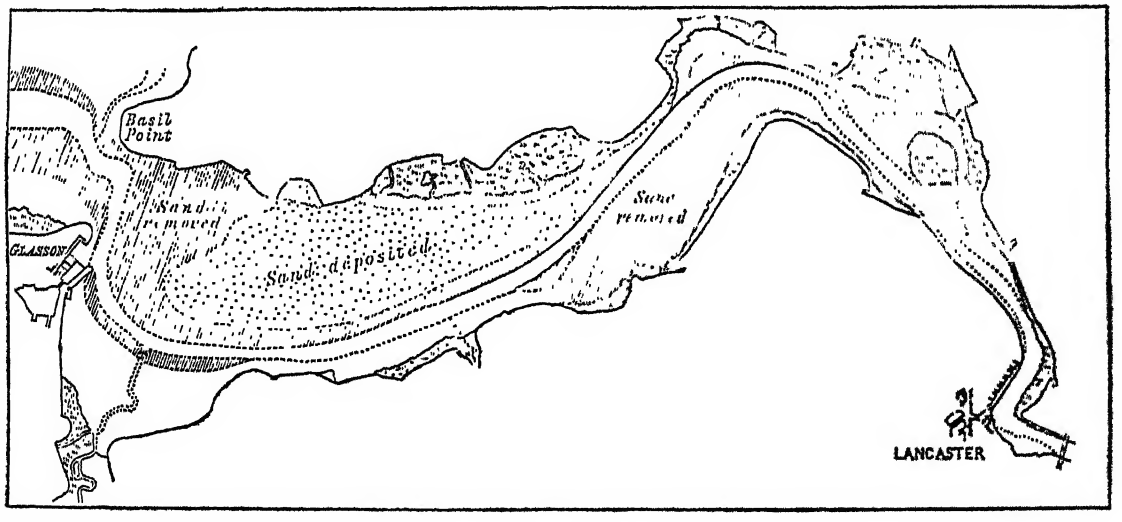

Fig. 24.

sary to determine the true state of the case. Figure 24 represents the changes that were produced by the works. Over the whole area which is represented as covered by sand a deposit had taken place, the banks being higher than formerly; whereas the whole area included in hatched lines had been scoured, the banks having been lowered. A careful calculation was made, founded on numerous sections taken in 1838, before the works commenced, and in 1851, after their completion. The result of this investigation was, that after the completion of the works, the amount of deposit on the space shown as sand in the cut was 3,070,146 cubic yards; while the amount of scour on the

[1] The mere cubic contents dredged from a ford or shoal often form no measure of the gain of tidal water due to the operations, because the removal of such an obstruction has the effect of lowering the low-water line for a considerable distance up the river, the extent to which the influence of the works extends depending on the amount of fall; and the whole of the wedge-shaped space included between the old and new low-water lines is a clear gain of tide-water, and the cubic contents of this space generally greatly exceed the cubic quantity of materials removed from the ford by dredging.

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space shown by hatched lines was 2,810,449 cubic yards; giving an excess of deposit of 259,697 cubic yards. But the amount stated as having been scoured does not include what has been taken away below Glasson and Basil points; and which has doubtless been deposited in the bank above. The survey of 1838 did not afford data for ascertaining the amount of what had been scoured from below Glasson with sufficient accuracy to admit of its being included in the foregoing calculations. But an amount of scouring was ascertained to have actually occurred at that place, which was amply sufficient to counterbalance the surplus of 259,697 cubic yards of deposit, as given in the above statement.

Such a result, we think, may indeed be expected; for it is difficult to conceive in what way parallel walls formed in an estuary can operate either in bringing down additional alluvial matters from the river above, or in bringing up additional detritus from without the bar.

Holding these views, and supported by the actual observations made in the case of the Lune, we therefore conclude—1*st*, That works executed in accordance with the principles laid down do not necessarily produce additional accumulation of matter, but *simply alter the disposition of the existing materials of which the bed of the estuary was originally composed.* 2*d*, By deepening the navigable track they admit of a large accession of water to act upon the low-water channel during all tides, and at the most favourable period of the tide. 3*d*, That the depth of water on such bars as are produced by the action of the waves may be maintained, and even increased, by means of the works which have been described as applicable to the intermediate or tidal compartments of rivers.

Size of particles transported proportional to velocity of stream.

While treating of deposits, this is probably the proper place to observe, that the size of detrital particles which can be carried by a current depends on the velocity of the stream, the nature of the bottom along which the detritus is moved, as well as the shape of the particles of which the detritus itself is composed, and is altogether a subject so dependent on special circumstances, that there is great difficulty in laying down rules which can be generally applicable. The following are the results of experiments made by Bossut, Dubuat, and others, on the size of detrital particles which streams flowing with different velocities are said to be capable of carrying:—

3 in. per sec.	=0·170	mile per hour will just begin to work on fine clay.
6 „ „	=0·340	do., will lift fine sand.
8 „ „	=0·4545	do., will lift sand as coarse as linseed.
12 „ „	=0·6819	do., will sweep along fine gravel.
24 „ „	=1·3638	do., will roll along rounded pebbles 1 inch in diameter.
3 ft. „	=2·045	do., will sweep along slippery angular stones of the size of an egg.

The only recent experiments made on this subject are those of Mr T. Login, C.E., given in the *Proceedings of the Royal Society of Edinburgh*, vol. iii., p. 475, which were made with a stream seldom exceeding half an inch in depth; and are as follows:—

Nature of Materials.	Rate of sinking in water.	Current required to move.	
	Feet per minute.	Feet per minute.	Mile per hour.
Brick-clay when mixed with water, and allowed to settle for half an hour	·566	15	·170
Fresh-water sand	10	40	·454
Sea sand	11·707	66·22	·752
Rounded pebbles about the size of peas	60	120	1·37
Vegetable soil	...	50	·56

Brick-clay in its natural state was not moved by a current of 123 feet per minute, or 1·45 mile per hour.

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We give these results as they have been stated by their authors; at the same time it is necessary to say that, for the reason above mentioned, we consider their application in practice to be very uncertain. Regarding the subject in a general point of view, however, certain laws as to the transmission and deposition of detritus will be found applicable to certain situations. On this subject Sir H. De la Beche says:[1]—"Where the velocity of a river is sufficient to produce attrition of the substances which it has either torn up, collected by undermining its banks, or which have fallen into it, they gradually become more easy of transport, and would, if the force of the current continued always the same, be forced forward until the river delivered itself into the sea; but as the velocity of a current greatly depends on the fall of the river, the transport is regulated by the inclination of the river's bed. Now it is well known that this inclination varies materially even in the same river; so that it may be able to carry detritus to one situation, but may be unable to transport it further under ordinary circumstances, in consequence of diminished velocity. As a general fact, it may be fairly stated that rivers, where their courses are short and rapid, bear down pebbles to the seas near them, as in the case of the Maritime Alps, &c.; but that where their courses are long, and change from rapid to slow, they deposit the pebbles where the force of the stream diminishes, and finally transport mere sand or mud to their mouths, as is the case with the Rhone, Po, Danube, Ganges, &c."

In rivers, lightest matters found next the sea.

This holds true in the case of such rivers as those to which Sir H. De la Beche refers; but it will be found that the case is exactly reversed in tidal estuaries. There the heavier sands and deposits are found at the mouth of the estuary, and the particles are lighter as we recede inwards. The writer has tested this on several occasions, more particularly in the Dee, the Ribble, the Lune, the Wear, the Forth, and the Tay, by agitating equal quantities of sand and deposit (taken from different parts of the tidal estuary) in equal quantities of water, and observing the time which elapsed in each case before the materials were deposited and the water assumed a state of purity. The result of these observations proved that the sand of outer or seaward banks was composed of large particles, which were held in suspension only a few seconds, and that in the inner parts of the estuary the deposit decreased in weight, and that *generally* it decreased from low to high water, where the silt was exceedingly fine, and remained in suspension in some cases even for hours after the agitation of the water. The following statement by Mr William Bald of experiments made on materials taken from different parts of the bed of the Clyde, shows the variety of materials found in the same stream, and is a valuable record of the weight of the deposits which form the beds of our tidal rivers:[2]—

The reverse of this the case in tidal estuaries.

Deposits.	Lbs. to cubic feet.	No. of cubic ft. to the Ton.
Fine sand and a few pebbles laid in the box, loose, not pressed, nearly dry	87	26
Do. do. pressed	92	24
Mud at White Inch, dry, and firmly packed; contained very fine sand and mica	97	23
Wet mud, rather compact and firm, well pressed into the box	115	19
Wet, fine sharp gravel, well pressed	124	18
Wet running mud	122½	18·1
Sharp dry sand deposit in harbour	92	24·3
Port-Glasgow Bank (sand) wet, pressed into a box	120½	18·6
Sand opposite Erskine House, wet, pressed	116	19·3
Alluvial earth, pressed	93	24
„ „ loose	67	33

The writer of this article found the gravel of the Tay to be 18 feet to the ton.

[1] De la Beche's *Geological Manual.*

[2] *Trans. of Institution of Civil Engineers*, vol. v., p. 330.

Quantity of matters in suspension.

The quantity of solid matter carried or held in suspension by rivers has also been made the subject of observation; but the different observers whose remarks have come under our notice have stated their results in different ways, some giving the *weight* and others the *bulk* of detritus. But assuming 18 cubic feet of solid matter to weigh a ton, we think the following table presents a fair view of the cubic measure of solid matter, and the ratios of volume and weight in each case. In submitting this table, we must observe that the discrepancies in the statements are so great, that further observations are necessary before any satisfactory conclusion can be arrived at; but we give the results as they have been stated by their respective authorities:—

Name of River.	Cubic inches of solid matter in every cubic yard of water.	Ratios of volume of solid matter to volume of water.	Ratios of weight of solid matter to weight of water.
Mississippi, mean...	15·5	$\frac{1}{3000}$	$\frac{1}{4000}$
Irrawaddy, in flood..	11·71	$\frac{1}{3972}$	$\frac{1}{4700}$
Do., ordinary state	4·1	$\frac{1}{11250}$	$\frac{1}{13200}$
Rhine, in flood	1·87	$\frac{1}{24650}$	$\frac{1}{29000}$
Do., ordinary state	1·13	$\frac{1}{40750}$	$\frac{1}{48000}$
Do., mean	1·5	$\frac{1}{30720}$	$\frac{1}{36200}$
Mersey, flood-tide...	29·	$\frac{1}{1600}$	$\frac{1}{2000}$ salt water
Do., ebb-tide.....	33·	$\frac{1}{1400}$	$\frac{1}{1750}$ salt water

From this table it will be seen that the Rhine, as compared to the others, is exceedingly pure; while the waters of the Mersey, on the other hand, hold in suspension a very large amount. It must be kept in view, however, that the source from whence the sedimentary matter in the Mersey is derived is very different from any of the other cases mentioned in the table. The main part of the solid matter in suspension in the Mersey, and indeed in all our tidal rivers, is sand, stirred up by the flowing tide, which is deposited again during the ebb-tide. The sedimentary matters in such rivers as the Mississippi or the Irrawaddy, on the other hand, are borne down from the low tracts of alluvial country through which it flows, and form a constant and consequently increasing deposit at the mouth of the river.[1]

Formation of deltas.

In all cases where the tidal currents across the mouths of such rivers are languid or altogether absent, as in the Mississippi, the Nile, the Danube, and other continental rivers, the deposits brought down are not carried away, but form deltas, which collect with greater or less rapidity in proportion to the quantity of material brought down and the depth of water in which it is deposited. Mr Ellet computes the delta of the Mississippi at 40,000 square miles in extent, its average length from north to south being 500 miles. Assuming the sedimentary matter brought down at $\frac{1}{3000}$th of the volume of water, and the discharge of the river at 21,000,000,000,000 cubic feet per annum, he estimates that this vast accretion of deposited stuff must have formed at an average rate of 1 mile in 99 years, giving a period for its entire formation of something like 45,000 years! Sir H. De la Beche has, however, with reason, suggested that deltas would increase most rapidly at the first period of their formation, on account of the greater declivity of the river, and the supposition that the detritus from the interior would become gradually less, from the equalization of levels and the fewer asperities that agents have to act on; and thus it seems impossible to calculate from the present rate of accretion the time which the whole mass has taken to accumulate.

Adjoining property benefited by river improvements.

In concluding this treatise, we have to point out in what way, and to what extent, river improvements conducted on the principles advocated benefit adjoining property; for it is obviously highly important if the two objects of *river* and *land* improvement can be carried on simultaneously, and we think that to a certain extent this is perfectly practicable. The attempts of proprietors to protect the foreshores of their lands from the encroachments of rivers in tidal estuaries are often attended with great expense; and if those efforts prove for some time effectual in warding off the approach of the channel, the land speedily takes on vegetation, and is fit for pasturage. But the tenure by which such property is held is very slight; and the spot which today affords grazing for cattle may in a few tides become the navigable channel of the river. Now, it is obvious that the perfect protection from such encroachments afforded by the training and guiding of the low-water channel by longitudinal walls, adds materially to the value of the adjoining property; for not only is the land beyond high-water mark completely protected from encroachment, but the marsh lands bordering the estuary become in fact *permanent property*, and not an ever-changing benefit held for one year and probably lost the next. Marsh lands so protected from waste are still, it is true, liable to be flooded by high tides, a circumstance, however, which is considered by some persons not injurious, but rather beneficial, for marsh pasture lands.

Level of vegetation on marsh lands.

The process of reclamation in all such cases goes on very slowly after it has reached a certain stage, because, as the banks rise, they are more seldom covered by the tide, and the materials deposited on the inner and higher parts of the banks are, as already stated, exceedingly fine, and are carried only by the highest tides, which seldom reach them. Mr Park has found on the Ribble that the first indications of vegetation appear when the banks are elevated 12 feet above the ordnance datum-line, which is the mean level of the sea. This height corresponds at the Ribble to about the level of high-water of neap tides. Mr Gordon[2] also found, that in the Norfolk estuary "the samphire began to settle on the sands, which the neap tides just cover," and that "grass began to grow about one foot above the samphire level." Such marsh lands, if left unprotected, must remain for ever liable to be covered during high floods or tides, and therefore cannot be said to be available as arable lands, without the erection of considerable works for the purpose of protecting them from floods, and providing for their effectual drainage. As the erection of such works, however, forms no part of river improvement, we allude to them in this place only for the purpose of remarking, that in all cases they should be erected with caution. There are situations in which the erection of embankments for protecting land may be injurious to the interests of navigation; there are others in which such works, if judiciously laid out, may be harmless; but their

[1] Mr Ellet says that the sedimentary matter transported by the Mississippi forms $\frac{1}{3000}$th part of the *volume* discharged by the river. (Ellet, *On the Ohio and Mississippi.*)—Mr T. Login, C.E., in Pegu, states in a paper on the Delta of the Irrawaddy, read before the Royal Society of Edinburgh, session 1857, that the waters of the Irrawaddy contained $\frac{1}{3972}$th part of their *weight* of sediment during floods, and $\frac{1}{11782}$th part of their *weight* when the river was in a low state, and gives the mean deposit at 8 inches per cubic yard.—Mr Leonard Horner found that the water of the Rhine at Bonn contained from $\frac{1}{24650}$th part of its weight during floods to $\frac{1}{40750}$th part of its weight in a low state. (*Arcana of Science and Art*, 1835.)—Captain Denham found that the tidal water of the Mersey contained 29 cubic inches of solid matter in every cubic yard during flood-tide, and 33 cubic inches in every cubic yard during ebb-tide. (*Observations on the Mersey*, by Captain H. M. Denham, R.N., Liverpool, 1840.)—Mr Lyell says:—"Hartsaeker computed the Rhine to contain, when most flooded, 1 part in 100 of mud in suspension. By several observations of Sir George Staunton, it appeared that the water of the Yellow River in China contained earthy matter in the proportion of 1 to 200. Manfredi, the celebrated Italian hydrographer, conceived the average proportion of sediment in all running water to be $\frac{1}{1000}$th. Some writers, on the contrary, as De Maillet, have declared the most turbid waters to contain far less sediment than any of the above estimates would import; and there is so much contradiction and inconsistency in the facts and speculations hitherto promulgated on the subject, that we must wait for additional experiments before we can form any opinion on the subject." (*Principles of Geology*, by Charles Lyell, F.R.S., London, 1830, vol. i., p. 247.)

[2] *Report on Norfolk Estuary*, by L. D. B. Gordon, C.E., Glasgow, 1856.

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effect in any case can only be determined by a careful consideration of the special circumstances of the locality in which they are erected. We know many cases where the interests of navigation have been sacrificed by unwarrantable encroachment; and, on the other hand, instances are not wanting where even important works have been embarrassed and crippled by an over-cautious regard to the principle of *non-encroachment* on the high-water line.

With reference more particularly to the operations of landowners, it is notorious that in many cases attempts to reclaim or protect property have led to serious and costly legal proceedings between landowners and the local conservators of navigations; and this we are sensible has in some instances arisen from a feeling, on the part of the landowners, that their operations could not be regarded as prejudicial. The local conservators, on the other hand, have generally no means of knowing what the ultimate intentions of the landowners are until their operations have proceeded so far as to render it impossible, if the interest of navigation require it, to stop or to remove the works without considerable loss. A difference of opinion has thus been raised, which has too often ended in an expensive lawsuit. We have long held the opinion that it would in many, if not in all, of our estuaries, be most desirable to have a line of conservation marked out by the Admiralty (without whose authority no encroachment can be made within high-water mark) for the regulation of all works for the protection of land. Were such a line defined, the landowners could then with confidence, and without risk of challenge, enter on such works within the line of conservation as they considered necessary for the protection of their property, and a source of much difference of opinion and expensive litigation would be at once removed. We had hoped that the Tidal Harbour Commission, who have been enabled, through the exertions of Captain Washington, the hydrographer of the Admiralty, who was one of the commission, to give in their printed reports so valuable a fund of information on our tidal harbours, would have terminated their labours by pointing out and recommending some such system as we have suggested of defining lines of conservation for all the important rivers and estuaries of the country. It is obvious, however, that were such a duty to be performed, it must be committed to a duly qualified commission, acting most naturally under the Admiralty, and so composed that the protection of navigation, and the interests of landowners or trustees for public works, should be fully represented, the whole of its members being actuated by one common desire to do what is best for the community at large.

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Discharges of Rivers.

The following is a statement of ratios between the discharges of certain rivers during low-water and when in flood; but it must be kept in view, as stated in treating of the formulæ for calculating the discharge, that its determination is a difficult problem; so that the results stated with reference to the discharge of different rivers must be received with this caution as to their accuracy.

	Mean Discharge. Cubic ft. per min.	Flood.	
Clyde	48,000	194,000	1 to 4·0
Conon	7,969	216,589	1 „ 27·2
Earn	54,000	215,600	1 „ 3·9
Ganges	12,420,000	29,652,480	1 „ 2·4
Irrawaddy	4,500,000	45,000,000	1 „ 10·0
Mississippi	39,954,000	76,800,000	1 „ 1·9
Nile	1,386,000	13,200,000	1 „ 9·5
Tay	218,000	753,740	1 „ 3·4
Thames	80,220	475,000	1 „ 5·9

The high ratio on the Conon may be due to the steepness of its bed, and the absence of any natural lake or reservoir on its course to act as a regulator.

The quantities in the following table represent the discharges of the rivers in their ordinary state.

Physical Characteristics of Rivers.

Name of River.	Length in miles.	Area of drainage in square miles.	Ordinary discharge per minute in cubic feet.	No. of cubic feet discharged per square mile of drainage.	Slope of surface in inches per mile.	Part of River where slope occurs.	Length of River affected by tide, in miles.	Depth on bar at low water, in feet.	Authority.
Amazon	4000	...	...	...	2·34	.....	400	...	N. Beardmore's Hyd. Tables.
Annan	35	...	...	...	66	Annan Waterfoot to Annan Bridge, 2 miles	2	...	Messrs Stevenson, C.E., Edin.
Boyne	60	700	180,000	257	...	.....	2	...	A. Nimmo, C.E.
Clyde	98	945	48,000	65	1½	Broomielaw to Port-Glasgow, 18 miles	22 above Port-Glasgow.	no bar	J. Ure, C.E., Glasgow.
Conon	35	399	7969	19·9	...	.....	...	...	Messrs Stevenson, Edin.
Coquet	44	...	...	...	60	.....	3¼	...	E. K. Calver, R.N.
Dee, Aberdeen	87	765	10,675	...	81	Lower part	...	...	J. Gibb.
Dee, Chester	85	620	...	...	11	Chester to Flint	32	East, West, 9 12	Messrs Stevenson, Edin. and Admiralty Report, by Captain Washington.
Forth	63 above Alloa.	452	29,385	75·7	11	Black Dub to Stirling	15 above Alloa	no bar	Messrs Stevenson.
Before works were execut.		...	...	...	13	Stirling to Alloa			
Foyle	55	1100	31,500	28·6	1·25	Londonderry to Culmore Pt.	23 above Londonderry.	...	Messrs Stevenson.
Ganges	1680	432,480	12,420,000	28·7	3·37	Rajmahal to Mirzapore Creek	...	...	Johnston's Physical Atlas. Beardmore's Tables. Rev. Mr Everest.
Irrawaddy	...	...	4,500,000	...	1·6	in summer	105	...	T. Login, C.E.
					3·8	in flood			
Lune	50	...	...	...	26·76	Glasson to Heaton, 3¼ miles	...	...	Messrs Stevenson.
Before works were execut.	...	...	...	...	20·	Heaton to Lancaster, 2¼ ...			
					24·	Average slope between Glasson and Lancaster...			
Mersey	70	1,748	...	...	...	.....	...	9 to 10	Captain Denham, R.N.
Mississippi	4400 includ. Missouri	1,226,600	39,954,000	32·5	2·8	ordinary flood from Ohio to Gulf of Mexico	...	...	C. Ellet.
					3·25				
Ness	7	700	...	...	96	Loch Dochfour to Kessock..	2	...	Messrs Stevenson.
Nile	2240	520,200	1,386,000	2·6	5·5	when high Cairo to Mediterranean...	...	...	N. Beardmore.
					3·25	when low..			Johnston's Physical Atlas.
Nith	45	...	...	...	20	Dumfries to Burron Point...	...	...	Messrs Stevenson.

Navigation Laws || Navigator's Islands.

Physical Characteristics of Rivers—Continued.

Name of River	Length in miles.	Area of drainage in square miles.	Ordinary discharge per minute in cubic feet.	No. of cubic feet discharged per square mile of drainage.	Slope of surface in inches per mile.	Part of River where slope occurs.	Length of River affected by tide, in miles.	Depth on bar at low water, in feet.	Authority.
Rhine	700	88,853	3,960,000	44·5	2119 119 63 20·7 7·7	Source to Reichenau..... Reichenau to Constance ... Constance to Basle ..... Basle to Cologne ..... Cologne to sea	...	...	Johnston's Physical Atlas. Beardmore's Tables. Falls and Discharge, from L. Horner, Esq.
Rhone	560	38,329	...	...	24·18	Besançon to Mediterranean	...	...	Johnston's Physical Atlas. Beardmore's Tables.
Ribble, before works	80	880	139,935	159	47·8	Lower 22½ miles	22½	5½	P. Park, C.E. Preston.
Severn	180	8,580	...	...	4·5 2 3 2 0·75 5 10·5 7·5 15 20·5 23·25 7	Diglis Weir to Upton Bridge Upton Bridge to Mythe Br. Mythe Bridge to Haw Br. Haw Bridge to Stonebench Stonebench to Rosemary Pt. Rosemary Pt. to Framilode Framilode to Newnham ... Newnham to Awre Point... Awre Point to Sharpness... Sharpness to Guscar..... Guscar to Inward Point ... Inward Pt. to Aust Head...	68	...	Remarks on the Tidal Phenomena of the River Severn, by Capt. F. W. Beechey, R.N.
Tay, before works	160	2,283	274,000	120	1·95 9·35 5·06	Flisk to Balmbreich..... Balmbreich to Newburgh Newburgh to Perth	35	18	Messrs Stevenson.
Tees	100	680	...	...	...	.....	22	6	John Murray, C.E.
Thames	204½ navigab.	5,000	102,000	20·4	20 ·92 109	Lechdale to Teddington ... Teddington to Yanlet Creek Confluence of Gala Water to Leader Water	66 from Nore.	no bar	Messrs Rennie, C.E.
Tweed	100	1,870	...	...	116 49	Leader to Kelso..... Kelso to sea	...	...	A. Peterman, F.G.S.
Tyne	80	1,100	...	...	...	.....	18	6	E. K. Calver, R.N.
Wear	58	437	9500	22	16	New Bridge to sea.....	10	2 to 4½	Thos. Meik, C.E., Sunderland.

(D. S—N.)

Navigator's Islands.

NAVIGATION LAWS, The, of which some notice has been given under the articles Commerce and England, and which were considered obnoxious to the interests of commercial enterprise, were in effect repealed in 1854. An act to admit foreign ships to the coasting trade of this country (17th Vict., cap. 5) was passed March 23, 1854; and an act to amend and consolidate the acts relating to merchant shipping (17th and 18th Vict., cap. 104) on the 10th August 1854. The latter act received some amendment, particularly with regard to the erection and maintenance of colonial lighthouses (18th and 19th Vict., cap. 91) in 1855.

NAVIGATOR'S ISLANDS, or Samoan Islands, a group in the Pacific, lying to the N.E. of the Friendly Islands, between S. Lat. 13. 30. and 14. 30., and W. Long. 168. and 173. They are eight in number, and three of them are of considerable size. The largest of the group is Savaii, which is upwards of 200 miles in circuit, and the principal others are Maoona, Pala, and Oyalava. They are for the most part mountainous and of volcanic formation. The soil is very rich and fertile, and the mountains are thickly covered with wood to their very summits. The trees are chiefly evergreens, and are remarkable for the beauty and variety of their appearance. Palms, cocoa-nut trees, breadfruit trees, banyans, sugar-canes, pine-apples, potatoes, coffee, yams, and tobacco are among the productions of these islands. The climate is variable, and heavy rains fall during the winter. No indigenous quadrupeds are found; but horses, cattle, and swine, which have been introduced from other places, thrive well and increase largely. Fowls are numerous, and the surrounding parts of the ocean abound in fish. The inhabitants are superior in appearance to most of the tribes of the South Sea Islands. They are stout, well-proportioned, and of a dark-brown complexion, and the men are in general better looking than the women. In character, they are generally good-natured, hospitable, and affectionate, and they show great respect for the aged. They are intelligent, and display considerable ingenuity in making their canoes and houses; but they are indolent, fond of pleasure, covetous, and deceitful. Their language is smooth and liquid, and in it alone of Polynesian tongues the sibilant sound occurs. The Navigator's Islands were first visited by missionaries in 1830 from Otaheite; and since 1836 missionaries have been sent out directly from Europe, by whose means a great number of the inhabitants have been converted to Christianity. They are also beginning to pursue the employments of trade, and to learn the use of money. Cocoa-nut oil is the principal article of export, and the imports are cotton, calicoes, fire-arms, ammunition, &c., supplied chiefly by American whalers. The whole area of the islands is 2650 square miles; and the estimates of the population vary from 50,000 to 160,000.

NAVY.

Navy. AN insular empire, like that of the united kingdom of Great Britain and Ireland, which is so much indebted, and always must be, for that power, prosperity, and renown which she enjoys, to the glorious deeds of her navy, cannot but take a peculiar degree of interest in every thing that concerns it. This vast machine, indeed, has at all times been the pride and boast of Great Britain, the terror of its enemies, and the admiration of the world. It is under the impression of its vast importance that we have been induced to give, under their proper heads, such details of the civil and military branches of the naval departments as may afford, without entering into too minute details, a comprehensive sketch of this great national bulwark, of which it is now proposed to take a general view.

The term NAVY is generally intended to express all ships of commerce as well as those of war, the mercantile as well as the military marine; but the observations contained in the present article are meant to relate only to the latter, excepting that, in speaking of the progressive enlargement of ships, and improvements in naval architecture, the remarks may sometimes equally apply to ships of commerce and of war.

NAVY composed of MATERIEL and PERSONNEL.

The composition of a navy may be considered under the two distinct heads into which it naturally divides itself, and under which the French generally distinguish an army, the *matériel*, and the *personnel*; the former embracing every thing that appertains to the ships, their capacity, construction, armament, and equipment; the latter all that concerns the rank, the appointment, the various duties, &c. of the officers, seamen, and marines.

I.—MATERIEL OF THE NAVY.

History. It would occupy too large a space to give even a short sketch of the origin and the progress of naval architecture, from a bundle of branches, or the hollow trunk of a tree—the rude raft and the frail canoe—to the more perfect coracle, or the wicker-boats of the ancient Britons, covered with hides. For many centuries after the expulsion of the Romans from, or their abandonment of, the British Islands, very little progress appears to have been made by us in the art of navigation or ship building: the natives would appear, for many centuries afterwards, to have acted merely on the defensive against naval invasions.

"The whole of our naval history," say the commissioners for revising the civil affairs of the navy, "may be divided into three periods; the *first* comprehending all that preceded the reign of Henry VIII.; the *second* ending with the restoration of Charles II.; and the *third* coming down from the Restoration to the present day."

First period. To what size, and to what extent, the amount of the English ships or vessels were carried, which supported so many contests with the invading Danes in the ninth century, our naval history has not preserved any record. We are told, however, that Alfred increased the size of his galleys, and that some of them were capable of rowing thirty pair of oars. These galleys were chiefly employed in clearing the Channel of the nests of pirates by which it was infested. It is also said, as a proof of his attention to naval matters, that, under his auspices, one Ochter undertook a voyage into the arctic regions, made a survey of the coasts of Lapland and Norway, and brought to Alfred an account of the mode pursued by the inhabitants of those countries to catch whales. It is, moreover, on record, that his two sons, Edward and Athelstan, fought many bloody actions with the Danes, in which several kings and chiefs were slain; and that Edgar had from three to five thousand ships, divided into three fleets, stationed on three several parts of the coast, with which, passing from one fleet or squadron to the other, he circumnavigated the island; that after this he called himself "Monarch of all Albion, and Sovereign over all the adjacent Isles." Some notion, however, may be formed of the size of the vessels which composed his fleets, from the imposition of a land-tax, which required certain proprietors to furnish a stout galley of three rows of oars, to protect the coast from the Danish pirates. The more effectually to check these marauders, and protect the coasts of the kingdom, William the Conqueror, in 1066, established the Cinque Ports, and gave them certain privileges, on condition of their furnishing fifty-two ships, with twenty-four men in each, for fifteen days, in cases of emergency. We should not, perhaps, be far amiss in dating the period of our naval architecture from the Conquest. "The Normans," says Sir Walter Raleigh, "grew better shipwrights than either the Danes or Saxons, and made the last conquest of this land; a land which can never be conquered whilst the kings thereof keep the dominion of the seas." But Raleigh does not describe what the ships were which the Normans taught us to build; nor can it now be known in what kind of vessels William transported his army across the Channel, or what was the description of the hundred large ships and fifty galleys of which the naval armament of Richard I. consisted on his expedition to the Holy Land. We are told, however, that having increased his fleet at Cyprus to two hundred and fifty ships and sixty galleys, he fell in with a ship belonging to the Saracens, of such an extraordinary size that she was defended by 1500 men, all of whom, with the exception of 200, Richard, after taking possession of her, ordered to be thrown overboard and drowned.

Matériel.

There can be no doubt that the nations of the Mediterranean, particularly the Genoese and Venetians, introduced many improvements as to the capacity and stability of their ships, in consequence of the crusades, and the demands for warlike stores and provisions which such vast and ill-provided armies necessarily created; but these improvements would seem not to have reached, or, at least, to have made but a tardy progress in, Great Britain. King John, it is true, stoutly claimed for England the sovereignty of the sea, and decreed that all ships belonging to foreign nations, the masters of which should refuse to strike to the British flag, should be seized and deemed good and lawful prize. And this monarch is said to have fitted out no less than five hundred sail of ships, under the Earl of Salisbury, in the year 1213, against a fleet of three times that number, prepared by Philip of France for the invasion of England; of which the English took three hundred sail, and drove a hundred on shore, Philip being under the necessity of destroying the remainder, to prevent their falling also into the hands of the English. Of the kinds of ships of which his fleet consisted, some notion may be formed by the account that is related of an action fought in the following reign with the French, who, with "eighty stout ships," threatened the coast of Kent. This fleet being discovered by Hubert de Burgh, governor of Dover Castle, he put to sea with forty English ships, and having got to

Matériel. the windward of the enemy, and run down many of the smaller ships, he closed with the rest, and threw on board them a quantity of quicklime, which blinded them so effectually that all their ships were either taken or sunk.

Whatever the size and the armaments of our ships were, the empire of the sea was bravely maintained by the Edwards and the Henrys in many a gallant and glorious sea-fight with the fleets of France, against which they were generally opposed with inferior numbers. The temper of the times, and the public feeling, were strongly exemplified in the reign of Edward I. by the following circumstance: An English sailor was killed in a Norman port, in consequence of which a war commenced, and the two nations agreed to decide the dispute on a certain day, with the whole of their respective naval forces. The spot of battle was to be the middle of the Channel, marked out by anchoring there an empty ship. The two fleets met on the 14th April 1293; the English obtained the victory, and carried off above two hundred and fifty sail.

In an action with the French fleet off the harbour of Sluys, Edward III. is said to have slain 30,000 of the enemy, and to have taken two hundred great ships, "in one of which only, there were four hundred dead bodies." This is no doubt an exaggeration. The same monarch, at the siege of Calais, is stated to have blockaded that port with seven hundred and thirty sail, having on board 14,956 mariners; twenty-five only of which were of the royal navy, bearing four hundred and nineteen mariners, or about seventeen men each. In various other sea actions did this great sovereign nobly support the honour of the British flag. But though we then, and ever after, claimed the "dominion of the seas," that dominion, says Raleigh, "was never absolute until the time of Henry the Eighth." It was a maxim of this great statesman, that "whosoever commands the sea, commands the trade of the world; whosoever commands the trade, commands the riches of the world, and consequently the world itself."

The reign of Henry V., however, was most glorious in maintaining the naval superiority over the fleets of France. From a letter of this sovereign to his lord chancellor, dated 12th August 1417, discovered by Samuel Lysons among the records in the Tower, and of which the following is a copy, it would appear that there was something like an established royal navy in his reign, independently of the shipping furnished by the Cinque Ports and the merchants, for the king's own use, on occasion of any particular expedition. The letter appears to have been written nine days after the surrender of the castle of Touque in Normandy, from whence it is dated.

"*Au revérend pere en Dieu l'Evesque de Duresme īre Chanceller d'Engleterre.*

"Worshipful fader yn God We sende you closed within this letter a cedule conteyning the names of certein Maistres for owr owne grete Shippes Carrakes Barges and Balyngers to the whiche Maistres We have granted annuitees such as is appointed upon eche of hem in the same Cedule to take yerely of owre grante while that us lust at owr Exchequer of Westmr. at the termes of Michelmasse and Ester by even porcions. Wherefore We wol and charge yow that unto eche of the said Maistres ye do make under owr grete seel beyng in yowre warde owr letters patentes severales in due forme after th'effect and pourport of owr said grante. Yeven under owr signet atte owr Castle of Touque the xij. day of August."

Extract from the Schedule contained in the preceding Letter.

vj. li. xiijs. iiijd. La Grande Nief appelle the dent John William est Maistre	vj. Mariners por la sauf garde deink Hamult.
vj. li. xiijs. iiijd. La Trinate Royale dont Steph' Thomas est Maistre	vj. Mariners.
vj. li. xiijs. iiijd. La Holy Gost dont Jordan Brownyng est Maistre	vj. Mariners.
vj. li. xiijs. iiijd. La Carrake appellee le Petre dont John Gerard est Maistre	vj. Mariners.
vj. li. xiijs. iiijd, La Carrake appellee le Paul dont William Payne est Maistre	vj. Mariners.
vj. li. xiijs. iiijd. La Carrak appelle le Andrewe dont John Thornyng est Maistr'	vj. Mariners.
vj. li. xiijs. iiijd. La Carrak appellee le Xpōfre dont Tendrell est Maistr'	vj. Mariners.
vj. li. xiijs. iiijd. La Carrak appelle le Marie dont William Richeman est Maistr'	vj. Mariners.
vj. li. xiijs. iiijd. La Carrak appellee le Marie dont William Hethe est Maistre	vj. Mariners.
vj. li. xiijs. iiijd. La Carrak appelle le George dont John Mersh est Maistr'	vj. Mariners.

Matériel.

The remainder, to the masters of which pensions were thus granted, consist of seventeen "niefs, barges, and ballyngers," some with three, and others two mariners only. But history informs us, that about this time Henry embarked an army of 25,000 men at Dover on board of 1500 sail of ships, two of which carried purple sails, embroidered with the arms of England and France; one styled the King's Chamber, the other his Saloon, as typical of his keeping his court at sea, which he considered as a part of his dominions. Still we are left in the dark as to the real dimensions of his ships, and the nature of their armament; they were probably used only as transports for his army. It would appear, however, from a very curious poem, written in the early part of the reign of King Henry VI. that the navy of his predecessor was considerable, but that, by neglect, it was then reduced to the same state in which it had been during the preceding reigns. The poem here alluded to is entitled "The English Policie, exhorting all England to keep the Sea, and namely the Narrow Sea; showing what profit cometh thereof, and also what worship and salvation to England and to all Englishmen;" and is printed in the first volume of Hackluyt's Collection of Voyages. It was evidently written before the year 1438, when the Emperor Sigismond died, as appears by the following passage in the prologue:

For Sigismond, the great Emperour,
Which yet reigneth, when he was in this land,
With King Henry the Fifth, Prince of Honour,
Here much glory, as him thought, he found
A mightie land, which had take in hand
To werre with France, and make mortalitie,
And ever well kept round about the sea.

The part of the poem which alludes to the navy of King Henry V. is entitled "Another incident of keeping the Sea, in the time of marveilous werriour and victorious Prince, King Henrie the Fifth, and of his great Shippes."

The following are the most remarkable passages:

And if I should conclude all by the King
Henrie the Fift, what was his purposing,
Whan at Hampton he made the great *dromons*,
Which passed other great ships of the Commons;
The *Trinitie*, the *Grace de Dieu*, the *Holy Ghost*,
And other moe, which as nowe be lost.
What hope ye was the Kings great intent
Of thoo shippes, and what in mind he meant:
It was not ellis, but that *he cast to bee*
Lorde round about environ of the see.
And if he had to this time lived here,
He had been Prince named withouten pere:

Matériel.

His great ships should have been put in preefe,
Unto the ende that he ment of in chiefe.
For doubt it not but that he would have bee
Lord and master about the round see:
And kept it sure, to stoppe our ennemies hence,
And wonne us good, and wisely brought it thence,
That no passage should be without danger,
And his licence on see to move and sterre.

Shortly after the time when this poem must have been written, it appears from the parliament roll (20th Henry VI. 1442), that an armed naval force, consisting only of eight large ships, with smaller vessels to attend them, was to be collected from the ports of London, Bristol, Dartmouth, Hull, Newcastle, Winchelsea, Plymouth, Falmouth, &c.; and, of course, the royal ships of 1417, the names of which are contained in the foregoing schedule, were then either gone to decay or dispersed. We are not to judge of the size of these ships from the few mariners appointed to each. These were merely the ship-keepers, or harbour-duty men, placed on permanent pay, to keep the ships in a condition fit for the sea when wanted.

It is very probable that, until our merchants engaged in the Mediterranean trade, and that the attention of the government was turned, in the reign of Henry VII. (about 1496), to imitate Portugal in making foreign discovery, under the skilful seaman Sebastian Cabot, very little was added to the capacity or the power of British ships of war. It is said, however, that on the accession of Henry VII. to the throne in 1485, he caused his marine, which had been neglected in the preceding reign, to be put into a condition to protect the coasts against all foreign invasions; and that, in the midst of profound peace, he always kept up a fleet ready to act. In his reign was built a ship called the Great Harry, the first on record that deserved the name of a ship of war, if it was not the first exclusively appropriated to the service of the state. This is the same ship which Camden has miscalled the Henry Grace de Dieu, and which was not built till twenty years afterwards, under the reign of Henry VIII. The Great Harry is stated to have cost L.14,000, and was burned by accident at Woolwich in the year 1553.

Second Period.

We now come to that period of our naval history in which England might be truly said to possess a military marine, and of which some curious details have been left us by that extraordinary man of business Mr Pepys, a commissioner of the navy, and afterwards secretary to Charles II., at a time when the king executed in person the office of lord high admiral, and also to James II. until his abdication. His minutes and miscellanies relative to the navy are contained in a great number of manuscript volumes, which are deposited in the Pepysian Library in Magdalene College, Cambridge. From these papers it appears, that in the thirteenth year of Henry VIII. the following were the names and the tonnage of the royal navy:

	Tons.
Henry Grace de Dieu	1500
Gabriel Royal	650
Mary Rose	600
Barbara	400
Mary George	250
Henry Hampton	120
The Great Galley	800
Sovereign	800
Catherine Forteleza	550
John Baptist	400
Great Nicholas	400
Mary James	240
Great Bark	250
Less Bark	180

Add to these two row-barges of sixty tons each, making, in the whole, sixteen ships and vessels, measuring 7260 tons. Matériel.

The Henry Grace de Dieu is stated in all other accounts, and with more probability, to have been only 1000 tons; the rule for ascertaining the measurement of ships being still vague, and liable to great error, was probably much more so at this early period. This ship was built in 1515, at Erith, in the river Thames, to replace the Regent, of the same tonnage, which was burned in August 1512, in action with the French fleet, when carrying the flag of the lord high admiral. There is a drawing in the Pepysian papers of the Henry Grace de Dieu, from which a print in the Archæologia has been engraved, and of which a copy has been taken as a frontispiece to C. Derrick's Memoirs of the Rise and Progress of the Royal Navy. From these papers it appears that she carried fourteen guns on the lower deck, twelve on the main deck, eighteen on the quarter-deck and poop, eighteen on the lofty forecastle, and ten in her sternports, making altogether seventy-two guns. Her regular establishment of men is said to have consisted of 349 soldiers, 301 mariners, and fifty gunners, making altogether 700 men. Some idea may be formed of the awkwardness in manœuvring ships built on her construction, or similar to her, when it is stated that, on the appearance of the French fleet at St Helens, the Great Harry, built in the former reign, and the first ship built with two decks, had nearly been sunk; and that the Mary Rose, of 600 tons, with 500 or 600 men on board, was actually sunk at Spithead, occasioned, as Raleigh informs us, "by a little sway in casting the ship about, her ports being within sixteen inches of the water." On this occasion the fleets cannonaded each other for two hours; and it is remarked as something extraordinary, that not less than three hundred cannon-shot were fired on both sides in the course of this action. From the prints above mentioned, which agree very closely with the curious painting of Henry crossing the Channel in his fleet to meet Francis on the Champ de Drap d'Or, near Calais, and now in the great room where the Society of Antiquaries hold their meetings in Somerset House, it is quite surprising how they could be trusted on the sea at all, their enormous poops and forecastles making them appear loftier and more awkward than the large Chinese junks, to which, indeed, they bear a strong resemblance. It is worth remarking that, in the year 1840, the position of the Mary Rose, near Spithead, was pointed out to that extraordinary diver Mr Deane, who went down several times, and brought up some beautiful pieces of brass ordnance, as perfect and as fine specimens as any we have at the present day.

Henry VIII. may justly be said to have laid the foundation of the British navy. He established the dock-yards at Deptford, Woolwich, and Portsmouth; he appointed certain commissioners to superintend the civil affairs of the navy, and settled the rank and pay of admirals, vice-admirals, and inferior officers; thus creating a national navy, and raising the officers to a separate and distinct profession. The great officers of the navy then were, the vice-admiral of England, the master of the ordnance, the surveyor of the marine causes, the treasurer, comptroller, general surveyor of the victualling, clerk of the ships, and clerk of the stores. Each of these officers had their particular duties, but they met together at their office on Tower Hill once a week, to consult, and make their reports to the lord high admiral. He also established the fraternity of the Trinity House, for the improvement of navigation and the encouragement of commerce; and built the castles of Deal, Walmer, Sandgate, Hurst Castle, &c. for the protection of his fleet and of the coast.

At the death of Henry VIII. in 1547, the royal navy consisted of about fifty ships and vessels of different sizes, the former from 1000 to 150 tons, and the latter down to

Matériel. twenty tons, making in the whole about 12,000 tons, and manned by about 8000 mariners, soldiers, gunners, &c. In the short reign of his son Edward, little alteration seems to have taken place in the state and condition of the royal navy. But the regulations which had been made in the reign of his father, for the civil government of naval affairs, were revised, arranged, and turned into ordinances, which form the basis of all the subsequent instructions given to the commissioners for the management of the civil affairs of the navy. In the reign of Mary the tonnage of the navy was reduced to about 7000 tons; but her lord high admiral nobly maintained the title assumed by England of Sovereign of the Seas, by compelling Philip of Spain to strike his flag that was flying at the main-top-mast head, though on his way to England to marry Queen Mary, by firing a shot at the Spanish admiral. He also demanded that his whole fleet, consisting of 160 sail, should strike their colours and lower their top-sails, as an homage to the English flag, before he would permit his squadron to salute the Spanish monarch.

The reign of Elizabeth was the proudest period of our naval history, perhaps surpassed by none previously to the Revolution. She not only increased the numerical force of the regular navy, but established many wise regulations for its preservation, and for securing adequate supplies of timber and other naval stores. She placed her naval officers on a more respectable footing, and encouraged foreign trade and geographical discoveries, so that she acquired justly the title of the Restorer of Naval Power, and Sovereign of the Northern Seas. The greatest naval force that had at any previous period been called together was that which was assembled to oppose the Invincible Armada, and which, according to the notes of Mr Secretary Pepys, consisted of 176 ships, with 14,992 men; but these were not all "Shippes Royall," but were partly composed of the contributions of the Cinque Ports and others. The number actually belonging to the navy is variously stated, but they would appear to have been somewhere about forty sail of ships, manned with about 6000 men. At the end of her reign, however, the navy had greatly increased, the list in 1603 consisting of forty-two ships of various descriptions, amounting to 17,000 tons, and manned with 8346 men. Of these, two were of the burden of 1000 tons each, three of 900 tons, and ten from 600 to 800 tons.

James I. was not inattentive to his navy. He warmly patronised Mr Phineas Pett, the most able and scientific shipwright that this country ever boasted, and to whom we undoubtedly owe the first essential improvements in the form and construction of ships. The cumbrous top-works were first got rid of under his superintendence. "In my owne time," says Raleigh, "the shape of our English ships hath been greatly bettered; in extremity we carry our ordnance better than we were wont; we have added crosse pillars in our royall shippes, to strengthen them; we have given longer floors to our shippes than in older times," &c. The young Prince Henry was so fond of naval affairs, that Phineas Pett was ordered by the lord high admiral to build a vessel at Chatham in 1604, with all possible speed, for the young Prince Henry to disport himself in, above London Bridge; the length of her keel was twenty-eight feet, and her breadth twelve feet. In 1610 Pett laid down the largest ship that had hitherto been built. She was named the Prince Royal; her burden was 1400 tons, her keel 114 feet, and she was armed with sixty-four pieces of great ordnance, "being in all respects," says Stowe, "the greatest and goodliest ship that was ever built in England." He adds, "the great workmaster in building this ship was Mr Phineas Pett, gentleman, some time master of arts, of Emanuel College, in Cambridge."

This excellent man, as appears from a manuscript account of his life in the British Museum, written by himself, was regarded by the shipwrights of the dock-yards, who had no science themselves, with an eye of jealousy; and a complaint was laid against him before the king, of ignorance in laying off a ship, and of a wasteful expenditure of timber and other matters. The king attended at Woolwich with his court, to inquire in person into the charges brought forward, and, after a painful investigation, pronounced in favour of Mr Pett. One of the charges was, that he had caused the wood to be cut across the grain; but the king observed, that, as it appeared to him, "it was not the wood, but those who had preferred the charges, that were cross-grained." Matériel.

The state of the navy at the king's death is variously given by different writers; but on this subject the memoranda left by Mr Secretary Pepys are most likely to be correct. From them it appears that, in 1618, certain commissioners were appointed to examine into the state of the navy, and by their report it appears there were then only thirty-nine ships and vessels, whose tonnage amounted to 14,700 tons; but in 1624, on the same authority, the numbers had decreased to thirty-two or thirty-three ships and vessels, but the tonnage increased to about 19,400 tons. The commissioners had, in fact, recommended many of the small craft to be broken up or sold, and more ships of the higher rates to be kept up.

The navy was not neglected in the troublesome reign of Charles I. This unfortunate monarch added upwards of twenty sail to the list, generally of the smaller kind; but one of them, built by Pett, was of a description, both as to form and dimensions, far superior to any that had yet been launched. This ship was the celebrated Sovereign of the Seas, which was launched at Woolwich in 1637. The length of her keel was 128 feet, the main breadth forty-eight feet, and from stem to stern 232 feet. In the description of this ship by Thomas Heywood, she is said to have "bore five lanthorns, the biggest of which would hold ten persons upright; had three flush-decks, a forecastle, half-deck, quarter-deck, and round-house. Her lower tier had thirty ports for cannon and demi-cannon; middle tier, thirty for culverins and demi-culverins; third tier, twenty-six for other ordnance; forecastle, twelve; and two half-decks, thirteen or fourteen ports more within board, for murthering pieces; besides ten pieces of chace ordnance forward, and ten right aft, and many loop-holes in the cabins for musquet-shot. She had eleven anchors, one of 4400 pounds weight. She was of the burden of 1637 tons." It appears, however, that she was found, on trial, to be too high for a good serviceable ship in all weathers, and was therefore cut down to a deck less. After this she became an excellent ship, and was in almost all the great actions with the Dutch; she was rebuilt in 1684, when the name was changed to that of Royal Sovereign; and was about to be rebuilt a second time at Chatham in 1696, when she accidentally took fire, and was totally consumed. In this reign the ships of the navy were first classed, or divided into six rates, the first being from 100 to sixty guns, the second from fifty-four to thirty-six, &c.

In 1642 the management of the navy was taken out of the king's hands, and in 1648 Prince Rupert carried away twenty-five ships, none of which ever returned; and such, indeed, was the reduced state of the navy, that at the beginning of Cromwell's usurped government, he had only fourteen ships of war of two decks, and some of these carried only forty guns; but, under the careful management of very able men, in different commissions which he appointed, such vigorous measures were pursued, that, in five years, though engaged within that time in war with the greatest naval power in Europe, the fleet was increased to 150 sail, of which more than a third part had two decks, and many of which were captured from the Dutch, and

Matériel. upwards of 20,000 seamen were employed in the navy. Our military marine was, indeed, raised by Cromwell to a height which it had never before reached; but from which it soon declined under the short and feeble administration of his son.

Though Cromwell found the navy divided into six rates or classes, it was under his government that these ratings were defined and established in the manner nearly in which they now are; and it may also be remarked, that, under his government, the first frigate, called the Constant Warwick, was built in England. "She was built," says Mr Pepys, "in 1649, by Mr Peter Pett (son of Phineas), for a privateer for the Earl of Warwick, and was sold by him to the state. Mr Pett took his model of this ship from a French frigate which he had seen in the Thames."

During the first period of our naval history, we know nothing of the nature of the armament of the ships. From the time of Edward III. they might have been armed with cannon, but no mention is made of this being the case. According to Lord Herbert, brass ordnance were first cast in England in the year 1535. They had various names, such as cannon, demi-cannon, culverins, demi-culverins, sakers, mynions, falcons, falconets, &c. What the calibre of each of these was is not accurately known, but the cannon is supposed to have been about sixty-pounders, the demi-cannon thirty-two, the culverin eighteen, falcon two, mynion four, saker five, &c. Many of these pieces, of different calibres, were mounted on the same deck, which must have occasioned great confusion in action in finding for each its proper shot.

Third period. On the restoration of Charles II. the Duke of York was immediately appointed lord high admiral, and by his advice a committee was named to consider a plan, proposed by himself, for the future regulation of the affairs of the navy, at which the duke himself presided. By the advice and able assistance of Mr Pepys, great progress was speedily made in the reparation and increase of the fleet. The duke remained lord high admiral till 1673, when, in consequence of the test required by parliament, to which he could not submit, he resigned, and that office was in part put in commission, and the rest retained by the king. Prince Rupert was put at the head of this commission, and Mr Pepys appointed secretary to the king in all naval affairs, and of the admiralty; and by his able and judicious management there were in sea-pay, in the year 1679, and in excellent condition, seventy-six ships of the line, all furnished with stores for six months, eight fireships, besides a numerous train of ketches, smacks, yachts, &c. with more than 12,000 seamen; and also thirty new ships building, and a good supply of stores in the dock-yards. But this flourishing condition of the navy did not last long. In consequence of the dissipation of the king, and his pecuniary difficulties, he neglected the navy on account of the expenses; the duke was sent abroad, and Mr Pepys to the Tower. A new set of commissioners were appointed, without experience, ability, or industry; and the consequence was, as stated by the commissioners of revision, that "all the wise regulations formed during the administration of the Duke of York were neglected; and such supineness and waste appear to have prevailed, that, at the end of not more than five years, when he was recalled to the office of lord high admiral, only twenty-two ships, none larger than a fourth rate, with two fireships, were at sea; those in harbour were quite unfit for service; even the thirty new ships which he had left building had been suffered to fall into a state of great decay, and hardly any stores were found to remain in the dock-yards."

The first act on the duke's return was the re-appointment of Mr Pepys as secretary of the admiralty. Finding the present commissioners unequal to the duties required of them, he recommended others. Sir Anthony Deane, the most experienced of the shipbuilders then in England, was joined with the new commissioners. To him, it has been said, we owe the first essential improvement in the form and qualities of ships of the line, having taken the model of the Superbe, a French ship of seventy-four guns, which anchored at Spithead, and from which he built the Harwich in 1664. Others, however, are of opinion that no improvement had at this time been made on the model of the Sovereign of the Seas after she was cut down. The new commissioners undertook, in three years, to complete the repair of the fleet, and furnish the dock-yards with a proper supply of stores, on an estimate of L.400,000 a year, to be issued in weekly payments; and in two years and a half they finished their task, to the satisfaction of the king and the whole nation; the number of ships repaired and under repair being 108 sail of the line, besides a considerable number of vessels of smaller size. The same year the king abdicated the throne, at which time the list of the navy amounted to 173 sail, containing 101,892 tons, carrying 6930 guns, and 42,000 seamen. Matériel.

The naval regulations were wisely left unaltered at the Revolution, and the business of the admiralty continued to be carried on chiefly, for some time, under the immediate direction of King William, by Mr Pepys, till the arrival of Admiral Herbert and Captain Russell from the fleet, into whose hands, he says, "he silently let it fall." Upon the general principles of that system, thus established with his aid by the Duke of York, the civil government of our navy has ever since been carried on.

In the second year of King William (1690), no less than thirty ships were ordered to be built, of sixty, seventy, and eighty guns each; and in 1697 the king, in his speech to parliament, stated that the naval force of the kingdom was increased to nearly double what he found it at his accession. It was now partly composed of various classes of French ships which had been captured in the course of the war, amounting in number to more than sixty, and in guns to 2300; the losses by storms and captures on our side being about half the tonnage and half the guns we had acquired. At the commencement of this reign, the navy, as we have stated, consisted of 173 ships, measuring 101,892 tons; at his death, it had been extended to 272 ships, measuring 159,020 tons, being an increase of ninety-nine ships and 57,128 tons, or more than one half both in number and in tonnage.

The accession of Queen Anne was immediately followed by a war with France and Spain, and in the second year of her reign she had the misfortune of losing a vast number of her ships, by one of the most tremendous storms that was ever known; but every energy was used to repair this national calamity. In an address of the House of Lords, in March 1707, it is declared as "a most undoubted maxim, that the honour, security, and wealth of this kingdom does depend upon the protection and encouragement of trade, and the improving and right encouraging its naval strength.....therefore we do in the most earnest manner beseech your majesty, that the sea affairs may always be your first and most peculiar care." In the course of this war were taken or destroyed about fifty ships of war, mounting 3000 cannon; and we lost about half the number. At the death of the queen, in 1714, the list of the navy was reduced in number to 247 ships, measuring 167,219 tons, being an increase in tonnage of 8199 tons.

George I. left the navy pretty nearly in the same state in which he found it. At his death, in 1727, the list consisted of 233 ships, measuring 170,862 tons, being a decrease in number of fourteen, but an increase in tonnage of 3643 tons.

George II. was engaged in a war with Spain in 1739, in consequence of which the size of our ships of the line

Matériel. ordered to be built was considerably increased. In 1744, France declared against us; but on the restoration of peace in 1748, it was found that our naval strength had prodigiously increased. Our loss had been little or nothing, whilst we had taken and destroyed, of the French twenty, and of the Spanish fifteen sail of the line, besides smaller vessels. The war with France of 1755 added considerably to the list, so that, at the king's decease, in 1760, it consisted of 412 ships, measuring 321,104 tons.

In the short war of 1762, George III. added no less than twenty sail of the line to our navy. At the conclusion of the American war in 1782, the list of the navy was increased to 600 sail; and at the signing of the preliminaries in 1783 it amounted to 617 sail, measuring upwards of 500,000 tons; being an increase of 185 ships and 157,000 tons and upwards since the year 1762. At the peace of Amiens the list of the fleet amounted to upwards of 700 sail, of which 144 were of the line. The number taken from the enemy, or destroyed, amounted nearly to 600, of which ninety were of the line, including fifty-gun ships, and upwards of two hundred were frigates; and our loss amounted to about sixty, of which six were of the line and twelve frigates.

The recommencement and long continuance of the revolutionary war, and the glorious successes of our naval actions; the protection required for our extended commerce, of which, in fact, we might be said to enjoy a monopoly, and for the security of our numerous colonies; contributed to raise the British navy to a magnitude to which the accumulated navies of the whole world bore but a small proportion. From 1808 to 1813, there were seldom less than from 100 to 106 sail of the line in commission, and from 130 to 160 frigates, and upwards of 200 sloops, besides bombs, gun-brigs, cutters, schooners, &c. amounting in the whole to about 500 sail of effective ships and vessels; to which may be added 500 more in the ordinary, and as prison, hospital, and receiving ships; making at least 1000 pendants, and measuring from 800,000 to 900,000 tons. The commissioners appointed to inquire into the state and condition of the woods, forests, and land revenues of the crown, state, in their report to parliament, in the year 1792, that, "at the accession of his majesty (Geo. III.) to the throne, the tonnage of the royal navy was 321,104 tons, and at the end of the year 1788 it had risen to no less than 413,467 tons." In 1808 it had amounted to the enormous extent of 800,000 tons, having nearly doubled itself in twenty years.

It must not, however, be supposed that the effective navy consisted of more than half this amount of tonnage. Since the conclusion of the war with France, it would appear that at least one-half of the number of ships then in existence had been sold or broken up as unfit for service; and as, by the list of the navy at the beginning of the year 1821, the number of ships and vessels of every description, in commission, in ordinary, building, repairing, and ordered to be built, had been reduced to 609 sail, we may take the greatest extent of the tonnage at 500,000 tons; but the greater part, if not the whole, of this tonnage was efficient, and in a state of progressive efficiency.

According to the printed list of the 1st January 1821, the 609 sail of ships and vessels appear to be as under:—

1st rates from	120	to	100	guns		23
2d " "	86	"	80	"		16
3d " "	78	"	74	"		90
4th " "	60	"	50	"		20
5th " "	48	"	22	"		107
6th " "	34	"	24	"		40
Sloops "	22	"	10	"		136
Making a total of						432
To which being added, gun-brigs, cutters, schooners, tenders, bombs, troop-ships, store-ships, yachts, &c.,						177
Grand total						609

In the year 1836 the total number of ships of war, including every description mentioned in the above list, amounted to about 560 sail; of which 95 were ships of the line in a state of efficiency for any service, or capable of being speedily put into a fit state for sea; and many of them were of a very superior class to any employed in the war. Matériel.

In the year 1846 there were 671 ships, including every description; and there are now (1857) on the list of the royal navy 735 ships, exclusive of those appropriated to harbour service, and of the coast-guard cruisers; making a grand total of 888 ships and vessels of all classes.

The increase in the size of our ships of war was unavoidable; France and Spain had increased theirs, and we were compelled, in order to meet them on fair terms, to increase the dimensions of ours; many of theirs were, besides, added to the list of our navy. The following sketch will show the progressive rate at which ships of the first order, or of 100 guns and upwards, were enlarged in their dimensions. In 1677 the first-rates were from 1500 to 1600 tons. In 1720 they were increased to 1800 tons. In 1745 we find them advanced to 2000 tons. During the American war they were raised to 2200 tons. In 1795 the Ville de Paris, of 110 guns, measured 2350 tons. In 1804 the Hibernia, of 110 guns, was extended to 2500 tons; and in 1808 the Caledonia, carrying 120 guns, measured 2616 tons, and here we stopped; but since then the Nelson, the Howe, the St Vincent, the Britannia, the Prince Regent, the Royal George, and the Neptune, have been built, all nearly of the same dimensions, and from the same draught—nine such ships as the whole world could not at the time produce. The French had one ship larger than any of these, called the Commerce de Marseilles. She was taken by us in Toulon, but broke her back in a gale of wind.

The following were the comparative dimensions of the Caledonia and the Commerce de Marseilles:—

Ships.	Length of Gun-deck.		Length of Keel.		Extreme Breadth.		Depth of Hold.		Tons.
	feet.	in.	feet.	in.	feet.	in.	feet.	in.	
Caledonia	205	0	170	9	53	8	23	2	2617
Commerce de Marseilles	208	4	172	0	54	9½	25	6½	2747

The armament of the Caledonia was as follows:—On the gun-deck she carried 32 guns, 32-pounders; middle-deck 34 24-pounders, upper-deck 34 24-pounders, carronades; quarter-deck 10 32-pounders, and 6 12-pounders, carronades; forecastle, 2 32-pounders, and 2 12-pounders, carronades. Her complement of men was 875.

At the commencement of the *third period*, we have a somewhat more precise account of the armament of our ships of war. On the 16th of May 1677, a committee of the Navy Board, Ordnance, and certain naval officers, recommended to his Majesty the following scheme for arming and manning the thirty new ships of the line ordered to be built by act of Parliament.

Guns.	1st Rates.	2d Rates.	3d Rates.
Cannon (supposed 42 prs.)	No. 26	...	...
Demi-cannon (32 prs.)	...	26	26
Culverins (18 prs.)	28	26	...
Twelve-pounders	...	...	26
Sakers, upper-deck	28	26	...
" Forecastle	4	...	4
" Quarter-deck	12	10	10
Three-pounders	2	2	4
Total	100	90	70

For the 1st rate	780 men
For the 2d do.	660 do.
For the 3d do.	470 do.

The rates of ships immediately after the revolution were reduced, the first being turned to second-rates, the second-

Matériel. rates to third, &c., and the size of each class more equalized. But from this time forward it was found impossible to preserve anything like uniformity in the several classes. So many ships captured from the French, Dutch, and Spaniards, were added to our navy, and so many new ones built after the models of ships taken from these maritime powers, that the various descriptions of ships of which our navy was composed became a very serious evil.

In the year 1745, a committee, composed of all flag-officers unemployed, of the commissioners of the navy who were sea-officers, under the presidency of Sir John Norris, and assisted by the master shipwrights, were ordered to meet, to consider and propose proper establishments of guns, men, masts, yards, &c., for each class of his Majesty's ships; and, according to their recommendation, the rates, armaments, and complements of his Majesty's ships were to be as follows:—

1st rates	100 guns	850 or 750	men.
2d „	90 „	750 „ 660	„
3d „	80 „	650 „ 600	„
	70 „	520 „ 460	„
4th „	60 „	420 „ 380	„
	50 „	350 „ 280	„
5th „	44 „	280 „ 220	„
6th „	24 „	160 „ 140	„

But this establishment was very soon departed from; for on the 3d of February 1747 the Board of Admiralty acquainted his Majesty, that the French ship Invincible, lately captured, was found to be larger than his Majesty's ships of 90 guns and 750 men; and suggested that this ship, and all other prizes of the like class, and also his Majesty's ships of 90 guns, when reduced to two decks and a-half, and 74 guns, should be allowed a complement of 700 men. And it further appears that at the latter end of the reign of George II. the rates of ships had undergone a very material alteration, for they consisted as under:—

1st rates	100 guns.	
2d „	90 „	
3d „	80 „	74—70—64 guns.
4th „	60 „	50 „
5th „	44 „	38—36—32 „
6th „	30 „	28—24—20 „

The scales for measuring the ships were as various as their rates; and the evil was further increased by the varieties which it was found necessary to introduce in the rigging and arming of the ships of war. The masts, yards, rigging, and stores, were of so many and various dimensions, as to be not only highly inconvenient, but extremely expensive. When Lord Nelson was off Cadiz with 17 or 18 sail of the line, he had no less than *seven* different classes of 74-gun ships, each requiring different-sized masts, sails, yards, &c., so that in the event of one of these being disabled, the others could not supply her with such stores as could be appropriated to her wants.

To remedy the many inconveniences resulting from the irregularities above mentioned, the lords of the Admiralty suggested, by their memorial to the Prince Regent, which, by his order in Council, of the 25th November 1816, was ordered to be carried into effect, that the ships of the navy should for the future be rated as under:—

The first rate to include all three-deckers, in as much as all sea-going ships of that description carry a hundred guns and upwards.

The second rate to include all ships of 80 guns and upwards, on two decks.

The third rate to include all ships of 70 guns and upwards, but less than 80 guns.

The fourth rate to include all ships of 50 and upwards, but less than 70 guns.

The fifth rate to include all ships from 36 to 50 guns.

The sixth rate to include all ships from 24 to 36 guns.

And that the complements of men be established as under:— Matériel.

1st rates	900 — 850 or 800	men.
2d „	700 or 650	„
3d „	650 „ 600	„
4th „	450 „ 350	„
5th „	300 „ 280	„
6th „	175 — 145 or 125	„

Of sloops, the complements established according to their size were to consist of 135, 125, 95, or 75 men; of brigs (not sloops), cutters, schooners, and bombs, 60 or 50 men.

Thus at that time stood the rating and manning of the navy; but it is now as follows, viz:—

Present Rating of the Navy.

Classes and Denominations of Her Majesty's Ships.

1. Rated ships, that is to say, ships registered on the list of the royal navy, under one of the six following rates:—

First-rates, to comprise all ships carrying 110 guns and upwards, or whose complements consist of 950 men or more.

Second-rates, to comprise one of her Majesty's yachts, and all ships carrying under 110 guns, and not less than 80 guns, or whose complements are under 950, and not less than 720 men.

Third-rates, to comprise her Majesty's other yachts, and all such vessels as may bear the flag or pennant of any admiral, superintendent, or captain superintendent of one of her Majesty's dockyards; and all ships carrying under 80 guns, and not less than 70; or whose complements are under 720, and not less than 600 men.

Fourth-rates, to comprise all ships carrying under 70 guns, and not less than 50, or whose complements are under 600, and not less than 440 men.

Fifth-rates, to comprise all ships under 50 guns, and not less than 30; or whose complements are under 440, and not less than 300 men; and

Sixth-rates, to consist of all other ships bearing a captain.

2. Sloops,—to comprise bomb-ships and all other vessels commanded by commanders.

3. All other ships commanded by lieutenants, and having complements of not less than 60 men.

Smaller vessels, not classed as above, to have such smaller complements as the lords commissioners of the Admiralty may from time to time direct.

The following is the present complement of ships:—

	Steam-vessels.	Sailing-vessels.
	Men.	Men.
1st rates	1050 to 1130	970
2d „	750 „ 930	720 to 850
3d „	600 „ 620	600 „ 650
4th „	475 „ 560	440 „ 500
5th „	300 „ 350	300 „ 375
6th „	180 „ 260	185 „ 275
Sloops	100 „ 165	80 „ 140
Smaller vessels	36 „ 90	50 „ 65

It is of the utmost importance, with a view to convenience and economy, that the size and dimensions of the several rates should be kept as nearly as possible equal, in order that one description of stores may be applicable to every ship of the same rate. To this end the commissioners of naval revision have recommended, "that the ships of each class or rate should be constructed, in every particular, according to the form of the best ship in the same class in our navy; of the same length, breadth, and depth; the masts of the same dimensions, and placed in the same parts of the ship, with the same form and size of the sails." A complete classification of masts, yards, and sails, has since been established.

The nine line-of-battle ships previously alluded to as "the largest the world could produce," are now far exceeded by the screw steam-ships recently built, and in course of construction,—viz., the Victoria, and Howe, each of 121 guns and 1000 horse-power; the Royal Sovereign, Prince of Wales, and Marlborough, each of 131 guns and 800 horse-power; and the Duke of Wellington, of 131 guns and 700 horse-power. Besides these, we have the

Matériel. Royal Albert, 121 guns, 500 horse-power; the Trafalgar, 120 guns; the Donegal, 101 guns, 800 horse-power; the Revenge, 91 guns, 800 horse-power; the St Jean d'Acre, 101 guns, 600 horse-power; the James Watt, Agamemnon, and Orion, each of 91 guns and 600 horse-power; the Princess Royal, 91 guns, 400 horse-power; the Shannon steam frigate, 51 guns, 600 horse-power; the Terrible (paddle), 21 guns, 800 horse-power; the Doris, 32 guns, 800 horse-power; and many other screw ships (including the Mersey and Orlando, both of the largest class frigates with an armament of 40 and 50 guns respectively). The large line-of-battle ships, however, are generally considered ill adapted for the ordinary purposes of war, and will probably be discontinued. The rapid increase of steam-ships in the Royal Navy has of late years been surprising, and probably ere long there will be no other class of ships or vessels afloat. Indeed this is nearly the case now. Steam corvettes and steam gun-boats supply the place of all the smaller class of vessels. There are at present 160 gun-boats on the list of the Royal Navy, of 20, 40, 60, and 80 horse-power.

Improvements in Construction.

If we look back to the days of Elizabeth, when the chain-pump, the capstan, the striking of the top-masts, the studding-sails, top-gallant-sails, sprit-sails, &c., were first introduced into the navy, one can scarcely conceive how they contrived to keep the sea for any length of time; but these improvements, important as they were, are trifling when compared with those aids and conveniences which have gradually been introduced since her reign, and which a ship of war now enjoys. When Sir Anthony Deane, in 1664, raised the lower ports of a two-decker four and a half feet out of the water, which had before been scarcely three feet, and made a ship of this class to stow six months' provisions instead of three, it was justly considered as a most important improvement; not less so, when the breadth of a ship of this class was carried to 45 feet. "The builders of England," says Pepys, "before 1673, had not well considered that breadth only will make a stiff ship." It must be confessed, however, that, as far as the form of a ship's bottom depends on scientific principles, we have copied our best models from the French, sometimes with capricious variations, which more frequently turned out to be an injurious alteration than an improvement.

The first essential alteration in the form of our ships of the line was taken from the Superbe, a French ship of seventy-four guns, which anchored at Spithead, on the model of which, as already stated, the Harwich was built by Sir Anthony Deane in 1674; since which time we have constantly been copying from French models, improving or spoiling, as chance might determine. "Where we have built exactly after the form of the best of the French ships that we have taken," say the commissioners of naval revision, "thus adding our dexterity in building to their knowledge in theory, the ships, it is generally allowed, have proved the best in our navy; but whenever our builders have been so far misled by their little attainments in the science of naval architecture as to depart from the model before them in any material degree, and attempt improvements, the true principles on which ships ought to be constructed (being imperfectly known to them) have been mistaken or counteracted, and the alterations, according to the information given to us, have in many cases done harm." Whilst, therefore, they add, "our rivals in naval power were employing men of the greatest talents and most extensive acquirements to call in the aid of science for improving the construction of ships, we have contented ourselves with groping on in the dark in quest of such discoveries as chance might bring in our way."

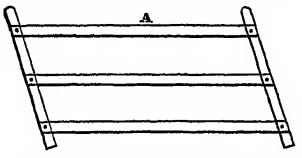
Upon these grounds, and by the recommendation of the commissioners, a school for a superior class of shipwright apprentices was established in Portsmouth dockyard. It consisted of twenty-five young men of liberal education, whose mornings were passed in the study of mathematics and mechanics, and in their application to naval architecture, and the remainder of the day under the master shipwright in the mould-loft, and in all the various kinds of manual labour connected with ship-building, as well as in the management and conversion of timber, so as to make them, at the same time, fully acquainted with all the duties in detail of a practical shipwright. After producing more officers than could be provided for, it was deemed expedient to break up the establishment. Matériel.

If, however, we had hitherto been inferior to the French in the scientific principles of ship-building, in the constructive part we left them behind beyond all comparison; and notwithstanding the narrow prejudices which have been more remarkably adhered to among shipwrights than among almost any other class of artizans, various alterations and improvements have from time to time been introduced into the mechanical part of naval architecture, which have added to the strength, the stability, the comfort, and convenience of our ships of war, and rendered them, in every point of view, superior to those of any other nation. The application of iron where wood was formerly used, and of copper for iron, has added considerably to the durability of ships; and the sheathing of their bottoms with copper, to their celerity, giving them at the same time a protection against the worm and those marine insects which were wont to adhere to them; yet it is remarkable how strong the prejudice was against this practice before it obtained a due degree of credit. In the fleet of Sir Edward Hughes in India there was but one coppered ship, and Rodney's squadron in the West Indies had but four that were coppered in the year 1782; but these were enough so completely to establish their superiority over the others with wooden sheathing, that in the year 1782 the whole British navy was coppered.

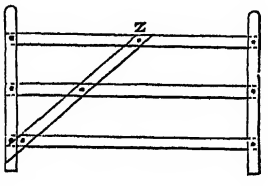
But the greatest of all improvements in the construction of ships of war, as tending to their strength and durability, is the system of diagonal bracing, first introduced by Mr (afterwards Sir Robert) Seppings, surveyor of the navy, and now universally adopted in all ships of the line and frigates,—a system that may be said to have established a new era in naval architecture. Of all large machines destined to undergo severe shocks, a ship is perhaps the least skilfully and artificially contrived. Her several parts are put together on a principle so much opposed to that which constitutes strength, that if a ship on the old construction should be put upon wheels, and drawn over a rough pavement, the action of a day would shake her in pieces; but being destined to move in an element that closes upon her, and presses her equally on all sides, she is prevented from falling in pieces outwards, and her beams and decks preserve her from tumbling inwards. Whoever has observed a ship *in frame*, as it is called, on the stocks—that is, with only her timbers erected—must be forcibly reminded of the skeleton of some large quadruped, as of a horse or ox, laid on its back; the keel resembling the backbone, and the curved timbers the ribs, which is, in fact, the name by which they sometimes go. These ribs, issuing at right angles from the keel, consist, in a seventy-four gun ship, of about 800 different pieces, the space between each rib seldom exceeding five inches. These ribs are covered with a skin or planks of different thicknesses within and without, also at right angles to the ribs, and fixed to them by means of wooden pins or tree-nails. In the inside three or four tiers of beams cross the skeleton from side to side, at right angles to both planks and ribs. These beams support the decks. At right angles to the beams are pieces of wood called carlings, and at right angles to these other pieces called ledges, and upon these the planks of the deck

Matériel. are laid in a direction at right angles to the beams, and parallel to the planking of the sides. From this sketch it will be perceived that all the parts of a ship are either parallel or at right angles to each other. The ribs form a right angle with the keel, the planks inside and out are at right angles to the ribs, the beams at right angles to these, the carlings to the beams, the ledges to the carlings, and the planks of the decks to the ledges, the beams, and the ribs.

Now, it is well known to every common carpenter that this disposition of materials is the weakest that can be adopted. Thus, if five pieces of wood be pinned together in the shape of a parallelogram, it will require but little force to move them from the rectangular to the oblique or rhomboidal shape.



But place a cross-bar, as in the figure Z, as carpenters are accustomed to do on a common gate, and it is no longer moveable on the points of fastening.



The strongest proof of a ship's partaking of this weakness in the old construction is afforded on her being first launched into the water, when it is invariably found that the two extremities, being less water-borne than the middle, drop, and give to the ship a convex curvature upwards, an effect which, from its resemblance to the shape of a hog's back, is usually called *hogging*. In very weak or old ships this effect may be discovered in all the port-holes of the upper-deck, by their having taken the shape of lozenges, declining different ways from the centre of the ship to each extremity.

To obviate this great defect, Seppings tried the experiment of applying to the ribs or timbers of the ship, from one extremity to the other, and from the orlop-deck downwards to the kelson, that well-known principle in carpentry, called *trussing*; being, in fact, a series of diagonal braces disposing themselves into triangles, the sides of which give to each other a mutual support and counteraction. These triangles were firmly bolted to the frame; and in order to give a continuity of strength to the whole machine, and leave no possible room for play, he filled the spaces between the frames with old-seasoned timber cut into the shape of wedges; but afterwards with a prepared cement, thus rendering the lower part of the ship or floor one solid complete mass, possessing the strength and firmness of a rock; but a few years have proved that this cement has injured the timber.

The same principle of trussing is carried from the gun-deck upwards, from whence, between every port, is introduced a diagonal brace, which completely prevents the tendency of ships to stretch, or draw asunder their upper works. The decks, too, are made subservient to the more firmly securing of the beams to the sides of the ship, by the planks being laid diagonally in contrary directions, from the midships to the sides, and at an angle of forty-five degrees with the beams, and at right angles with the ledges.

In frigates and smaller vessels, iron plates, lying at an angle of forty-five degrees with the direction of the trusses, are substituted for the diagonal frame of wood in ships of the line.

By this mode of construction, the ceiling or internal planking is wholly dispensed with, and a very considerable saving of the finest oak timber thereby effected; and, what is more important, those receptacles of filth and vermin between the timbers, which were before closed up by the planking, are entirely got rid of. This is not the least important part of the improvement, either as it concerns the soundness of the ship or the health of the crew. It is stated that a ship which had been three years in India, on being laid open, exhibited a mass of filth, mixed up with dead rats, mice, cockroaches, and other vermin, which was taken out in cakes, not unlike in appearance the oil-cake with which certain animals are fed; that the stench was abominable, and the timbers with which it was in contact rotten. No such filth can find a lodgment in ships of war as they are now built. Matériel.

It has been a subject of discussion amongst ship-builders, whether tree-nails or metallic fastenings are to be preferred. The objection to iron bolts is their rapid corrosion, from the gallic acid of the wood, the sea-water, and perhaps by a combination of both; in consequence of which the fibres of the wood around them become injured, the bolts wear away, the water oozes through, and the whole fabric is shaken and disarranged. This corrosion of iron fastenings was most remarkable when the practice of sheathing ships with copper became general, and when iron nails were made use of to fix it; for, by the contact of the two metals in the sea-water a galvanic action took place, and both were immediately corroded. Mixed metal nails are now used for this purpose; and copper bolts are universally employed below the line of flotation, though it is found that in these also oxidation takes place to a certain degree, and causes partial leaks. Various mixtures of metals have been tried, but all of them are considered as liable to greater objections than pure copper. It would appear, then, that tree-nails, if properly made, well seasoned, and driven tight, are the least objectionable, being seldom found to occasion leaks, or to injure the plank or timbers through which they pass. This species of fastening has at all times been used by all the maritime nations of Europe. The Dutch were in the habit of importing them from Ireland, it being supposed that the oak grown in that country was tougher and stronger than any which could be procured on the Continent, and in all respects best adapted for the purpose. "Under all circumstances," says Mr Knowles, "it appears that the present method of fastening ships generally with tough, well-seasoned tree-nails, with their ends split, and caulked after being driven, and securing the buts of each plank with copper bolts well clenched, is liable to fewer objections, and more conducive to the durability of the timber, than any other which has been tried or proposed to be established." Fastenings.

Rounding the form of the bow in ships of the line is considered by nautical men as of great utility and importance. The plan was first proposed by Seppings in 1807, and has since been generally adopted. The removal of the head railing, and the continuing of the rounded form, give not only great additional strength to the ship, but also much more comfort and convenience to the crew, and security in that part of the ship when in action. Round bows to ships of the line.

The scarcity of compass or crooked timber was, for some time, attended with serious injury to those ships of war while on the stocks, into which it was considered necessary to be introduced. The difficulty with which it was procured, the length of time which a ship sometimes remained on the stocks waiting for a few pieces of compass timber, the green wood, when found, being immediately added to the seasoned timber in other parts of the frame, gave to the ship different periods of durability; though, in the long run, the seasoned parts became affected by the green wood with which they were in contact, and a premature decay of the whole fabric was the consequence. Seppings, therefore, proposed a plan in 1806, which, by uniting short timbers according to a method called *scarphing*, enabled him to obtain every species of compass-form that could be required from straight timber. Since that period, the whole frame of a ship can be prepared at once, without waiting for particular pieces, and thus every part of it can be made to undergo an equal degree of seasoning. Scarphing a substitute for compass timber.

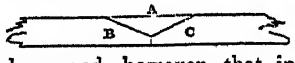
Matériel.

Plan for rendering frigate timber applicable to ships of the line.

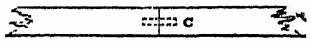
By the same ingenious and indefatigable surveyor of the navy, a plan was proposed and adopted in the year 1813, by which ships of the line were built with timber hitherto considered as applicable only to the building of frigates, and that which had been deemed only fit for inferior uses was appropriated to principal purposes. The Talavera was the first ship built on this principle, and the expense of her hull is stated to have been about L.1000 less than that of the Black Prince, a ship of similar dimensions built upon the old principle. The method by which the timbers were united was found, on trial of the Talavera with the Black Prince, whilst in frame, to give so much additional strength to the former, that it furnished the groundwork of the present mode of framing the British navy, by the introduction of the same union of materials in the application of the large as was practised in that of the small timber, and from which both strength and economy have been united.

Use of chocks abolished.

The building of the Talavera, and the great strength of her frame, led to the practice of putting together the frames of ships of the line from timbers of reduced lengths, and dispensing altogether with the chocks used for uniting their extremities, or, as they are technically called, their *heads and heels*. These chocks are of the form of an obtuse wedge, as A, and they are used to unite the two pieces of timber, as B and C, by firmly bolting the piece A to the two timbers B and C.



It generally happened, however, that in the operation of thus fixing this chock its two extremities split, and the surfaces of the chock and timbers not being in perfect contact, the moisture and the air were admitted, and occasioned, as they always do, the dry rot to a greater degree in those parts of the ship than in most others; and as there were from 400 to 500 of these chocks in a 74-gun ship, it will readily be conceived what mischief was done to the whole fabric, if the greatest care was not taken by the workmen to prevent their splitting, and to bring their surfaces immediately into contact. It is obvious, also, that a great deal of timber must have been cut to waste in making these chocks; and, in fact, they consumed timber in each ship, when it was at a high price, to the value of from L.1500 to L.2000, besides a considerable expense in workmanship; and when the ship came to be repaired, not one chock in six was found to be in a fit state to be used again. It is not easy to conceive how this practice of uniting the timbers of a ship's frame came to be introduced so generally into the British navy, more especially as it is unknown in any other nation. It was probably first adopted to preserve the length of some particular timber, one of the ends of which being defective, the unsound part may have been cut away in the manner represented, and the sound chock introduced to fill up the vacuity. But it is quite surprising how a practice should have become general which creates a waste of timber, an increase of workmanship, and sows the seeds of premature decay. To obviate these disadvantages, Sir Robert Seppings brought the butt ends of the timbers together thus—



and kept them together by means of a round dowal or coak, as C, just as the fellies of a carriage-wheel are fastened together. He justly observes, that the simplicity of the workmanship, the economy in the conversion of timber, and the greater strength and durability, although of considerable moment, are of but trifling importance when compared with the advantage of rendering timber generally more applicable to the frames of ships which had heretofore but been partially so.

Another great improvement in the construction of ships of war, introduced by Seppings, is the round stern, which, however unsightly it may at first appear, from our being accustomed to view the square stern, with its grotesque carved work, is even in appearance more consistent with the termination of the sweeping lines of a ship's bottom than the cutting them off abruptly with a square stern. But the additional strength which is thus given to a ship in that part which was hitherto the weakest, is alone sufficient to recommend the adoption of the plan in our ships of war, particularly in those of the larger classes. The advantages gained by circular sterns are thus enumerated by Sir Robert Seppings:—

Matériel.

Round stern.

1. They give additional strength to the whole fabric of a ship.
2. They afford additional force in point of defence.
3. They admit of the guns being run out in a similar way to those in the sides.
4. From the circular form, and mode of carrying up the timbers, an additional protection against shot is obtained if the ship should be raked.
5. The stern being equally strong as the bow, no serious injury can accrue in the event of the ship being pooped; and the ship may be moored, if so required, by the stern.
6. A ship will sail better upon a wind, from the removal of the projections of the quarter galleries.
7. Ships of the line have now a stern-walk, protected by a veranda, and so contrived that the officers can walk all round, can observe the set of the sails, and the fleet in all directions.
8. The compass-timber heretofore expended for transoms is replaced with straight timber, and worked nearly to a right angle, which affords a considerable saving in the consumption of timber.
9. The counter being done away by the circular stern, the danger from boats being caught under it is obviated.

In fact, the circular stern possesses many other advantages not necessary to be enumerated in this place.

Iron knees.

Another important improvement in the interior construction of ships has been the substitution of iron in lieu of the clumsy wooden knees for the support of the decks.

Classification of masts and yards.

Sir William Symonds, who was many years surveyor of the navy, and who greatly improved the build of ships of all classes, assisted by Mr Edie, was the first to reduce to a system and classify the masts and yards, the advantage of which cannot be overrated.

Armament.

In the same way the armament of a ship is now brought more into a system, and it is no longer necessary to alter the fittings of the ports to allow of elevating and depressing the guns. These, and many other similar systematic arrangements—simple enough, it must be admitted—are of very recent introduction into the service.

The names of Oliver Lang, his son Oliver W. Lang, (who has built the fastest steam-vessels afloat), Fincham, and Roberts, master-shipwrights of the several yards, are also closely connected with various important improvements in ship-building in the Royal Navy.

Improvements in the Preservation of the Navy.

Not only is the new mode of construction highly favourable to the duration of ships, but the ravages of the disease which is known by the name of the dry rot, occasioned principally by the hurry in which ships were built in the course of the French war, and the unseasoned state of the timber made use of (see Dry Rot), led to such measures as tend most effectually to the preservation of the fleet.

By prevention of dry rot.

In the first place, various modes were put in practice for assorting and seasoning the timber, and for protecting it from the vicissitudes of the weather. The oak and fir of Canada, which had been introduced to a great extent into our dockyards during the time the Baltic was shut against this country, are now excluded; these woods having been

Matériel. found not only to possess little durability, but to be so friendly to the growth of fungi that they communicated the baneful disease to all other descriptions of timber with which they came in contact. The practice of building ships under cover, introduced into our dockyards in the course of the said war, and carried to an extent so as to have roofed over almost every dock and slip in all the yards, has been preventive of the progress of dry rot. (See DOCKYARDS.)

By precautions in ordinary. A ship now placed in ordinary, whether new or newly repaired, is carefully housed over, so that no rain can reach her lower decks; several streaks of planks are removed from her sides and decks to admit a thorough draft of air, which is sent down by wind-sails, and which pervades every part of the ship: and these, with the addition of two small airing-stoves, in which a few cinders are burned, render her perfectly dry and comfortable on all the decks and store-rooms. All the shingle ballast is removed out of the hold, which is thoroughly cleaned and re-stowed with iron ballast. The former practice of mooring two ships together, by which the two sides next to each other, deprived of the sun and a free circulation of air, were generally found to be decayed, is discontinued. The lower masts are left standing, and their tops housed over; the gun-carriages and several of the stores are left on board; and such, in short, is the state of a ship in ordinary, that she may be fitted in all respects for proceeding to sea in half the usual time. "The ships," says Mr Knowles, "are frequently pumped to clear them of bilge-water, and cleanliness in every respect is attended to; the lower decks are rubbed with dry stones, commonly called *holly-stones*, and with sand, the use of water upon them being strictly forbidden." But that which most of all is likely to insure the preservation of the fleet whilst in the state of ordinary, is the recent regulation which places the ordinary under the immediate superintendence of a captain at each port, with other commissioned officers under his orders, who take care that the warrant-officers and ship-keepers attend to the proper airing, ventilating, and keeping clean and dry their respective ships.

By immersion of timber in salt water. A practice had been introduced into the dockyards of steeping oak timber in salt water for several months, and then stacking it till it became perfectly dry, which is said to have entirely put a stop to the progress of dry rot where it had already commenced, and to have acted as a preventive to that disease. Some doubts, however, were entertained on this point, and the practice has been discontinued. The Americans seem to place little confidence in the good effects which are said to have been experienced from the immersion of timber. Rodgers, the commissioner of their navy, stated in an official report addressed to the secretary, that "experiments have been made to arrest the dry rot in ships, by sinking them for months in salt water, but without success. The texture of the wood was found to be essentially injured by being thus water-soaked, and it became more subject to this disease than before it was sunk. The ships were also injured in their fastenings, and the atmosphere within them was kept in a constant state of humidity, whence, among other ill effects, proceeded injury to provisions and stores, and sickness to the crews." The truth is, the American timber, with the single exception, perhaps, of the live-oak, is remarkably subject to dry rot, of which, during the war with France, we had fatal experience. Mr Rodgers, however, accounts for the condition in which the oak and pine were received in England from Canada by their immersion in water. "The Canada timber," he observes, "is brought down the St Lawrence in large rafts, continues months in water, and in that saturated state is landed and exposed to frost; every attempt to season it under cover is unavailing; its pores never close again, and when used as ship-timber dry rot ensues, which, when once commenced, can never be arrested but by taking out all the pieces in any degree affected." The Russians, he says, are so fully aware of the injurious effects of soaking ship-timber in water, that it is brought from great distances down the rivers in crafts instead of rafts. The Russian ships, however, with all this precaution, are not remarkable for durability. The ships built at Antwerp by the French were in a state of rottenness before they were launched; but whether this was owing to the bad quality of the timber of the German forests, or to its being water-soaked in rafting down the Rhine, remains doubtful. But we can have no doubt that porous timber is injured by moisture, though the solid British oak may be improved by the dissolution of its sap juices, to the fermentation of which the disease known by name of dry rot may perhaps be chiefly owing. "Water," says Lescalier, a French writer of considerable merit on the subject, "seems to be favourable to the decomposition of the sap of timber when immersed; but it substitutes in its place another kind of moisture not less destructive, of which the timber, though afterwards exposed to the air, will not easily get rid; besides, it weakens and destroys the grain of the wood." "The best means," he adds, "of preserving timber, appears to be that of keeping it in well-constructed and airy sheds, in a vertical position, so that the moisture which remains in the interior of the logs, by running along the fibres of the wood, may be enabled to issue from the lower extremity. Timber thus kept dry, under shelter, will preserve itself for ages." Mr Knowles, secretary to the committee of surveyors of his Majesty's navy, in his treatise on the *Means of Preserving the British Navy*, is led to conclude, from a variety of experiments, "that timber is better seasoned when kept for two years and a half under cover, than when placed for six months in water, and then for two years in the air, protected from the rain and sun; that it loses more in seasoning by having been, during the six months of immersion, alternately wet and dry, than the whole time under water; and that the loss in moisture is greater in all cases in a given time when the butt ends are placed downwards." And he adds, as a general principle, "that no timber should be brought into use in this country until it has been felled at least three years." Sir William Burnett, many years physician of the navy, produced a solution for the preservation of timber and canvas, which has been found in many cases efficacious.

Matériel.

By roofing the ships. Next to the system of diagonal braces, the roofing thrown over them whilst building and in ordinary may be considered as the greatest of all improvements for the preservation of the navy. The utility of it is so obvious, that it is quite extraordinary such a practice should not have been earlier adopted; more especially as at Venice, at Carlscrona, and at Cronstadt, ships of war had long been built, repaired, and protected under covered roofs. It was strongly recommended to the English ship-builders sixty or seventy years ago, but without effect; and had it not been for the extraordinary ravages of the dry rot in the unseasoned timber-built ships of the navy, we should still have been without roofs to our docks and slips.

By other means. If the dockyards were of sufficient capacity, there can be no doubt that the efficient plan to accomplish their durability would be that of keeping them on the slip, when built, under cover. A large frigate, the Worcester, remained on the slip and under cover for six or seven years, and there was not a flaw in her of any kind. It was stated by Mr Strange, when examined by the commissioners for land revenue, that in the year 1790 there were twenty-two ships of the line under roofs in the port of Venice, some of which had remained in that situation fifty-nine years. Since, however, it is utterly impracticable to keep our navy on slips or in dry docks, the next important consideration is, how best to preserve them afloat in a state of ordinary. Various expedients have been at different times resorted to in order to prevent the premature decay of ships laid up in this state during peace. The two great requisites for their preserva-

Matériel. tion are ventilation and cleanliness. To promote the former, wind-sails were in general use; though, if not attended to, so as to oppose the open part to the quarter from whence the wind blows, or if the weather be calm, they are of little benefit. Pneumatic machines of various kinds, as pumps and bellows, have been applied to force out the foul air, and introduce atmospherical air into the lower parts of a ship's hold. Heated air from stoves, placed in various parts of the ship, and conducted through tubes, was thought at one time to be efficacious in the preservation of the navy; but experience soon showed that the heat thus circulated was so far objectionable, as it tended to encourage the growth of fungus where there was any moisture lodged, and in the timber which had not been thoroughly seasoned. Perhaps no better means can be suggested than those we have described to be in practice,—namely, to keep them clean, to admit as much dry air as possible, and to exclude all moisture.

Finally, if we take into consideration the numerous improvements which a war, unparalleled in its duration, had been the means of introducing into the *matériel* of the navy, whether it regards the economy of its application, the construction of the ships, or their mode of preservation, we may safely say, that at no former period was this country in possession of such a navy as after the close of the war with France, in respect of the number, size, and good condition of the ships which compose a fleet superior to those of the whole world besides; and it is gratifying to find that, with all the enormous consumption of the military and mercantile navy, it does not appear that the naval resources of Great Britain were at that time at all impaired. The present state of the navy, at the close of another great war, in which its resources were in some respects severely tried, is no less satisfactory.

Naval Resources.

It is of essential importance that the supply of stores for the use of the fleet should not only be adequate to the demand, but that a sufficient stock should be kept on hand to answer any sudden emergency. This is the more necessary with regard to those species of stores which are derived from foreign nations.

Principal naval stores. The principal articles of consumption required for building and equipping a fleet are,—hemp, canvas, pitch, tar, iron, copper, and timber. All these articles might unquestionably be produced in sufficient quantities in the united kingdom and her colonies, if necessity absolutely

Hemp. required it. Hemp, for instance, might be grown to any extent in Great Britain and Ireland, were not the land more advantageously employed in raising other articles of consumption, and if it could not be cheaper imported from Russia. In the East Indies, the Sunn hemp (inferior, it is true, to Russian hemp) might be procured to any extent; and other plants, both there and at home, might be substi-

Pitch and tar. tuted for the making of cordage and canvas. For pitch and tar recourse might be had to the pitch-lake on the island of Trinidad, and the coal-tar, of which an inexhaustible supply may be had at home. The lake is about four miles in circumference, and many feet in depth, of solid pitch; and it is stated that, when mixed with oil or tallow, it is rendered fit for all the purposes to which pitch and tar are usually applied. It has the advantage of securing ships' bottoms against the attack of the worm, which is very active in the neighbouring gulf of Para; and it does not corrode iron. The coal-tar of home manufacture, from some prejudice or other, was refused a fair trial till very lately, and it is now deemed not inferior for many purposes to the common tar. For painting or tarring over woodwork of every kind, it is said to stand exposure to the weather even better than the common tar; and it is used for injecting, in large quantities, between the timbers of ships, as a preservative from the dry rot; its powerful smell having also the good effect of driving rats and other vermin out of the ships in which it is employed. Matériel.

Copper and iron. In the two important articles of copper and iron, our own resources may be considered as inexhaustible. Formerly it was deemed indispensable that certain articles should be made of Swedish iron; but of late years our own has been manufactured in every respect equally good; and the extensive application of this metal in bridges, barges, dock-gates, roofs, rafters, floors, &c., has been equally progressive in most naval purposes. Iron knees, and other modes of binding the beams to the side timbers of ships, are now substituted for those large and crooked pieces of timber, as already stated, which were once deemed absolutely necessary. Our cables, rigging, buoys, and tanks for holding water, are also now of iron. A few steam-vessels have also Iron ships. been constructed of iron; but from experiments made by firing at them, they have been found wholly unsuited for purposes of war, the shot passing through their side, and leaving frightful rents, which, if struck between wind and water, would speedily cause them to fill and sink. It is therefore assumed that they will be discontinued in the Royal Navy.

Timber. But the most important article of demand for the use of the navy is timber, principally oak, concerning the supply of which from our own territories different opinions have been entertained. A deficiency in other articles may readily be supplied. A failure in the importation of hemp, for instance, in any one year, might be remedied the next, by an extended cultivation of that article; but it requires a whole century to repair any defalcation of oak timber, and to render us independent of other nations. Nor has the subject been sufficiently elucidated, so as to form a just opinion, by the several committees of the House of Commons, the evidence produced being almost always loose, and generally contradictory. The committee of 1771, which was directed to inquire into the state of oak timber throughout the kingdom, either from a disagreement of opinion, or defect of evidence, or a wish to avoid giving alarm, prayed the House to discharge that part of its order which required them to report their opinion. The Commissioners of Woods and Forests, however, in their report laid before Parliament in 1792, appeared to establish the fact of an alarming scarcity of oak timber in general, but more particularly of large naval timber, both in the royal forests and on private estates. And if such was really the fact in 1792, it will readily be conceived what the state of timber fit for naval purposes must have been at the conclusion of the revolutionary war, when the amount of private shipping had increased from 1,300,000 tons to 2,500,000 tons, or nearly doubled; that of the East India Company, in the same period, from 79,900 tons to 115,000 tons; and that of the navy from 400,000 to 800,000 tons: to say nothing of the vast consumption of oak timber in all kinds of mill-work and other machinery; in the barrack and ordnance departments; in mines, collieries, and agriculture; in docks and dock-gates; in piers, locks, and sluices; in boats, barges, lighters, bridges, and a great many other purposes to which this timber is applied. From these and many other causes, the diminution of oak timber was infinitely greater than the commissioners had calculated upon, and yet they recommended that 100,000 acres belonging to the crown should be set apart and planted for the future supply of the navy. A bill to this effect, relating to the New Forest, passed the Commons, but was thrown out by the Lords.

Report of the Commissioners of Land Revenue respecting timber. On the departments of the surveyor-general of the land revenue and the surveyor-general of the woods and forests being united, the board of commissioners made their first report, which was printed, by order of the House of Commons, in June 1812. In this report, it is stated that, taking the tonnage of the navy in 1806 at 776,087 tons, it would require, at one load and a half to a ton, 1,164,085 loads to build such a navy; and supposing the average duration of

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a ship to be fourteen years, the annual quantity of timber required would be 83,149 loads, exclusive of repairs, which they calculate would be about 27,000 loads, making in the whole about 110,000 loads; of which, however, the commissioners reckon, may be furnished 21,341 loads as the annual average of prizes; and of the remaining 88,659 loads, they think it not unreasonable to calculate on 28,659 from other sources than British oak. "This," they observe, "leaves 60,000 loads of such oak as the quantity which would be sufficient annually to support, at its present unexampled magnitude, the whole British navy, including ships of war of all sorts, but which may be taken as equivalent together to 20 74-gun ships, each of which, one with another, contains about 2000 tons, or would require, at the rate of a load and a half to the ton, 3000 loads, making just 60,000 loads for 20 such ships."

Quantity of timber required for the navy.

Now it has been supposed that not more than forty oak trees can stand on an acre of ground, so as to grow to a full size, fit for ships of the line, or to contain each a load and a half of timber; 50 acres, therefore, would be required to produce a sufficient quantity of timber to build a 74-gun ship, and 1000 acres for 20 such ships; and as the oak requires at least 100 years to arrive at maturity, 100,000 acres would be required to keep up a successive supply for maintaining a navy of 700,000 or 800,000 tons. The commissioners further observe, that as there are 20,000,000 of acres of waste lands in the kingdom, a two-hundredth part set aside for planting would at once furnish the whole quantity wanted for the use of the navy.

This calculation, we suspect, is overrated by about one-half. In the first place, it supposes a state of perpetual war, during which the tonnage of the whole navy is considered as more than double of what it is in time of peace; and in the second place, it reckons the average duration of the navy at fourteen years only, which, from the improvements that have taken place in the construction and preservation of ships of war, with the resources of teak ships, built in India, we should not hesitate in assuming at an average of twice that number of years; and if so, the quantity of oak required for the navy will be nothing like that which the commissioners have stated. This, we think, will appear from a statement made (apparently on good authority) in the midst of the war, when the ships of the line built in merchants' yards were falling to decay after a service of five or six years.

"Assuming 400,000 tons as the amount of tonnage to be kept in commission, and the average duration of a ship of war at the moderate period of twelve and a half years, there would be required an annual supply of tonnage, to preserve the navy in an effective state, of 32,000 tons; and as a load and a half of timber is employed for every ton, the annual demand will be 48,000 loads. The building of a 74-gun ship consumes about 2000 oak trees, or 3000 loads of timber; so that 48,000 loads will build eight sail of the line and sixteen frigates. Allowing one-fourth part more for casualties, the annual consumption will be about 60,000 loads, or 40,000 full-grown trees, of which thirty-five will stand upon an acre of ground. The quantity of timber, therefore, necessary for the construction of a 74-gun ship will occupy fifty-seven acres of land, and the annual demand will be the produce of 1140 acres. Allowing only ninety years for the oak to arrive at perfection, there ought to be now standing 102,600 acres of oak plantations, and an annual felling and planting, in perpetual rotation, of 1140 acres, to meet the consumption of the navy alone. Large as this may seem, it is little more than twenty-one acres for each county in England and Wales, which is not equal to the belt which surrounds the park and pleasure-grounds of many estates."

The above calculation proceeds upon the principle that every acre is covered with trees fit for naval purposes, or that it contains thirty-five trees, with a load and a half of timber in each. It may be doubted, however, if on the average of plantations we shall find more than one-tenth of that number on an acre; and as the same writer endeavours to show that the quantity of oak timber consumed in the navy is only about one-tenth part of the whole consumption of the country, instead of 102,600 acres being sufficient for a perpetual supply, there would be required some ten or twelve millions of acres, in plantations similar to those at present existing, to supply the demand for oak timber. Whether such a quantity exists or not, the fact is certain, that, before the conclusion of the long war, a scarcity began to be felt, especially of the larger kind of timber, fit for building ships of the line; and so great was this scarcity, that if Sir Robert Seppings had not contrived the means of substituting straight timber for those of a certain form and dimension, before considered as indispensable, the building of new ships must have entirely ceased.

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If, however, the growth of oak for ship-timber was greatly diminished during the war, so as to threaten an alarming scarcity, there is little doubt that, from the increased attention paid by individuals to their young plantations, and the great extension of those plantations, as well as from the measure of allotting off portions of the royal forests to those who had claims on them, and inclosing the remainder for the use of the public, this country will, in future times, be fully adequate to the production of oak timber equal to the demand for the naval and mercantile marine. It will require, however, large and successive plantations, on account of the slow growth of the oak. But there is another tree, of late years very generally planted on rising grounds, which bids fair to become an object of great national importance, as furnishing the best, and perhaps the only substitute for oak timber. We mean the larch, which thrives well and grows rapidly in bad soils and exposed situations, the timber of which has been found to be durable, and, from several experiments, not inferior in strength, toughness, and elasticity to oak. So rapid is its growth, that the Duke of Atholl received twelve guineas for a single larch fifty years old; the timber was valued at two shillings a foot. A larch of seventy years' growth produces timber fit for all naval purposes, and may be considered as equal in size to an oak of double that age. The dimensions of a larch tree cut down at Blair Atholl in 1817, and then seventy-nine years of age, were as follows, viz.:—Stem, 82 feet; top, 20 feet; total height, 102 feet; girth at the ground, 12 feet; at 19 feet, 8 feet 3½ inches; and at 57 feet, 4 feet 10 inches: solid contents, 252·8 cubic feet. Another larch, growing at Dunkeld, measured, in the year 1819, when it was eighty years old, and in full vigour, as follows, viz.:—Height of stem, 75 feet; top, 14 feet; total height, 90 feet; at 1 foot from the ground, 17 feet 8 inches in girth; at 10 feet, 10 feet 4 inches; and at 70 feet, 3 feet 2 inches: its contents, 300 cubic feet, or six loads. For all kinds of mill-work, as wheels, axle-trees, &c., the utility of the large larch wood is unquestionable; and the thinnings are excellent for paling, rails, and hurdles. The value of its application for naval purposes has been put to the test of experiment; two frigates of 28 guns, one built entirely of larch from the Duke of Atholl's plantations, the other of Riga fir (which was considered inferior only to oak), having been intended to go through the same service, precisely in the same parts of the world, in order to ascertain their comparative durability. What was the result of the experiment we are not aware, beyond the fact, that the Atholl, which was one of the frigates, is still a good, sound ship, in commission at Greenock, though built, we believe, some forty years ago.

Value of larch for shipbuilding.

In addition to our resources of naval timber at home, we have wisely availed ourselves of those which India affords for building ships of war at Bombay, of teak, a wood far superior in every respect to oak, and many times more durable, not

Indian teak.

Personnel. liable to corrode iron or other metallic fastenings, not susceptible of the dry rot, nor subject to the attack of the worm.

II.—PERSONNEL OF THE NAVY.

The *personnel* of the navy is composed of two different bodies of men, the seamen and the marines, each of whom have their appropriate officers.

The officers of the navy are divided into two distinct branches—the military and the civil. The military, or executive branch, consists of flag-officers, commodores, captains, commanders, lieutenants, masters of the fleet, masters, mates, second masters, midshipmen, masters' assistants, naval cadets, gunners, boatswains, carpenters.

Commissioned officers. Flag-officers are divided into three ranks, and each rank into three squadrons, distinguished by the colours red, white, and blue: as admiral of the red, white, or blue; vice-admiral of the red, white, or blue; rear-admiral of the red, white, or blue: the admiral wearing his colour at the main, the vice-admiral at the fore, and the rear-admiral at the mizen mast head. There is also an admiral of the fleet, who, if in command, would carry the union flag at the main. There are, besides, flag-officers on reserved half-pay, divided into three ranks, to which they rise by seniority; and superannuated rear-admirals, enjoying the rank and pay of a rear-admiral, but incapable of rising to a higher rank on the list, which is considered a grievance. The rank of commodore is temporary: he is generally an old captain, and is distinguished by wearing a broad pennant. He ranks next to the junior rear-admiral, and above all captains, except where the captain of the fleet shall be a captain who, in that situation, takes rank next to the junior rear-admiral.

The commissioned officers of the navy take rank with those of the army as follows:—

Navy.	Army.
Admiral of the fleet	Field-Marshal.
Admiral	General.
Vice-admiral	Lieutenant-General.
Rear-admiral	Major-General.
Commodore (1st and 2d class)	Brigadier-General.
Captain of three years	Colonel.
Captain under ditto	Lieutenant-Colonel.
Commander	Major.
Lieutenant, Master	Captain.
Mate	Lieutenant.
Second Master, Midshipmen	Ensign.

And all officers of the same rank command according to the priority of their commissions, or, having commissions of the same date, according to the order in which they stand on the list of the officers of the navy; except in the case of lieutenants of flag-ships, who take precedence according as the flag-officer shall think fit to appoint them.

The civil branch consists of the director-general of the medical department of the navy (who ranks with a brigadier-general), medical inspectors of hospitals and fleets, and deputy-medical inspectors (who rank with lieutenant-colonels and majors), chaplains, secretaries to commanders-in-chief and commodores of first class, surgeons, paymasters (formerly pursers), assistant surgeons, assistant paymasters, naval instructors, clerks, clerks' assistants, inspectors of machinery, chief engineers, and assistant engineers of 1st, 2d, and 3d class.

Warrant-officers. The warrant-officers of the navy may be compared with the non-commissioned officers of the army. They take rank as follows, viz.:—Gunner, boatswain, carpenter.

Petty officers. The petty officers are very numerous; they consist of chief petty officer, and 1st and 2d class working petty officers. Their names or ratings will be seen in the table of the establishment of the ratings and pay in the several classes of ships of war.

By the Queen's order in Council, the following regulations are established for the promotion of commissioned officers of the navy. Midshipmen are required to serve five years on board some of Her Majesty's ships, three years and six months of which they must have been rated as midshipmen, to render them eligible to the rank and situation of lieutenant; and they must be nineteen years of age. They enter the navy between the age of thirteen and fifteen as naval cadets, in which rank they are required to serve eighteen months, the first three of which in a training ship; and at the end of the five years they are rated mates, and so continue till promoted. There are several intermediate examinations required to be passed by them. Personnel. Order of promotion.

No lieutenant can be promoted to the rank of commander until he has been on the list of lieutenants during two years, and has served that period at sea; and no commander to the rank of captain until he has been on the list, and has served at sea one year. Captains become admirals in succession according to their seniority on the list, provided they shall have commanded four years in a rated ship during war, or six years during peace, or five years in war and peace combined.

No person can be appointed to serve as master of one of Her Majesty's ships who shall not have served as second master; and no person can be appointed as second master until he has passed such examination as may from time to time be directed.

No person can be appointed gunner unless he shall have served seven years, one of which as gunner's mate or other petty officer, or seaman gunner, on board one or more of Her Majesty's ships; and he must produce certificates of his good conduct, and undergo the necessary examination.

No person can be appointed boatswain unless he shall have served seven years,—one complete year with the rating, and actually doing the duty of a petty officer in Her Majesty's navy; and he must produce certificates of good conduct, and undergo the necessary examination.

No person can be appointed carpenter unless he shall have served an apprentice-ship to a shipwright, and been six months a carpenter's mate or caulker, or twelve months with the rating of carpenter, on board one or more of Her Majesty's ships.

No person can be appointed chaplain to one of Her Majesty's ships until he has received priest's orders; but he may be appointed to act whilst in deacon's orders.

No person can be appointed paymaster unless he shall have been rated, and have discharged the duties of a captain's clerk for three complete years; or two years as captain's clerk, and one year clerk to a secretary of a flag-officer; and been employed in the office of the secretary to a flag-officer for one other year; and shall produce good certificates, and find such security for the honest and faithful discharge of his duty as shall be required.

No person can be appointed surgeon to one of Her Majesty's ships until he has discharged the duties of assistant-surgeon for three years, one of which at sea; and all persons applying for the situation of assistant-surgeon must undergo an examination touching their qualifications before the medical director-general of the navy.

Royal Marines. The Royal Marines, recently made light infantry, consist of four great divisions; the first stationed at Chatham, the second at Portsmouth, the third at Plymouth, and the fourth at Woolwich. They are composed of 104 companies besides fourteen companies of Royal Marine artillery, whose head-quarters are at Portsmouth. The first division has twenty-five companies, the second twenty-seven companies, the third twenty-seven companies, and the fourth twenty-five companies. The officers of Royal Marines take rank with the officers of the line in the army.

The deputy adjutant-general, who is a major-general, and the assistant adjutant-general, who is a lieutenant-colonel in the corps, are resident in London; and to each

Personnel.

of the divisions is attached a colonel-commandant and a colonel and second commandant, a proper number of lieutenant-colonels, captains, and subaltern officers. Whilst on shore the marines are subject to the same regulations as the army; but when embarked they are liable to the naval articles of war, and to the Marine Mutiny Act.

Each division has two or more adjutants; two quarter-masters, who are all first lieutenants; a paymaster, who is a captain in the corps; and barrackmaster, also a captain; and to each division is a deputy-inspector of hospitals, or staff-surgeon and two assistant-surgeons. There is also a retired list of officers, who, in consideration of wounds, infirmities, and long and meritorious services, are permitted to receive their full pay, and also a reserved half-pay list.

The commissions of officers of every rank in the marine corps are signed by the sovereign; but all commissions of officers of the navy are signed by two or more of the lords commissioners of the Admiralty. But the marines, whether ashore or afloat, are, as well as the officers of the navy, under the immediate direction and control of the lords commissioners of the Admiralty. All the appointments of commissioned and warrant officers to ships are made exclusively by the lords of the Admiralty, or made subject to their confirmation, unless in cases of the death or dismissal of officers by sentence of court-martial on foreign stations, when the admiral commanding has the power to fill up the vacancies. And the duties of each rank are pointed out in a code of instructions emanating from that board, and sanctioned by the sovereign's order in Council.

Military duties of the Lord High Admiral.

The civil powers and duties of the Lord High Admiral, or lords commissioners of the Admiralty, are treated of under the article ADMIRAL. Their military powers are more extensive and important. By their orders all ships are built, repaired, fitted for sea, or laid up in ordinary, broken up, or sold; put in commission or out of commission, armed, stored, and provisioned; and employed on the home or foreign stations, or on voyages of discovery. All appointments or removals of commission and warrant officers are made by them, and all instructions issued for the guidance of their commanders; all promotion in the several ranks emanates from them; all honours bestowed for brilliant services, and all pensions, gratuities, and superannuations for wounds, infirmities, and long services, are granted on their recommendation. All returns from the fleet are sent to the Board of Admiralty, and everything that relates to the discipline and good order of every ship. All orders for the payment of naval monies are issued to the accountant-general of the navy by the lords commissioners of the Admiralty; and the annual estimate of the expenses of the navy is prepared by them, and laid before Parliament for its sanction. All new inventions and experiments are tried by their orders before being introduced into the service; all draughts of ships must be approved by them; all repairs, alterations, and improvements in the dockyards, and all new buildings of every description, must be submitted for their decision before they are undertaken.

Commander-in-chief.

All flag-officers, commanders-in-chief, are considered as responsible for the conduct of the fleet or squadron under their command. They are bound to keep them in perfect condition for service; to exercise them frequently in forming orders of sailing and lines of battle, and in performing all such evolutions as may occur in the presence of an enemy; to direct the commanders of squadrons and divisions to inspect the state of each ship under their command; to see that the established rules for good order, discipline, and cleanliness, are observed; and occasionally to inquire into these and other matters themselves. They are required to correspond with the secretary of the Admiralty, and report to him all their proceedings.

If a commander-in-chief should be killed in battle, his flag is to be continued flying, and intelligence conveyed, by signal or otherwise, to the next in command, who is immediately to repair on board, leaving his own flag (if a flag-officer) flying, and direct the operations of the fleet until the battle be ended, or the enemy out of sight. Personnel.

Other flag-officers.

Every flag-officer serving in a fleet, but not commanding it, is required to superintend all the ships of the squadron or division placed under his orders; to see that their crews are properly disciplined; that all orders are punctually attended to; that the stores, provisions, and water, are kept as complete as circumstances will admit; that the seamen and marines are frequently exercised; and that every precaution is taken for preserving the health of their crews; for all which he is responsible to the commander-in-chief. When at sea, he is to take care that every ship in his division preserve her station, in whatever line or order of sailing the fleet may be formed; and in battle he is to observe attentively the conduct of every ship near him, whether of the squadron or division under his immediate command or not; and at the end of the battle he is to report it to the commander-in-chief, in order that commendation or censure may be passed, as the case may appear to merit; and he is empowered to send an officer to supersede any captain who may misbehave in battle, or whose ship is evidently avoiding the engagement. If any flag-officer be killed in battle, his flag is to be kept flying, and signals to be repeated, in the same manner as if he were still alive, until the battle shall be ended; but the death of a flag-officer, or his being rendered incapable of attending to his duty, is to be conveyed as expeditiously as possible to the commander-in-chief.

Captain of the fleet.

The captain of the fleet is a temporary rank, where a commander-in-chief has ten or more ships of the line under his command; it may be compared with that of adjutant-general in the army. He may either be a flag-officer, or one of the senior captains; in the former case, he takes his rank with the flag-officers of the fleet; in the latter, he ranks next to the junior rear-admiral, and is entitled to the pay and compensation of a rear-admiral. All orders of the commander-in-chief are issued through him, all returns of the fleet are made through him to the commander-in-chief, and he keeps a journal of the proceedings of the fleet, which he transmits every three months to the Admiralty. He is appointed and can be removed from his situation only by the lords commissioners of the Admiralty.

Commodore.

A commodore is a temporary rank, and of two kinds; the one having a captain under him in the same ship, and the other without a captain. The former has the rank, pay, and allowances of a rear-admiral, the latter such additional pay as the lords of the Admiralty may direct. They both carry distinguishing pennants.

Captain.

When a captain is appointed to command a ship of war, he commissions the ship by hoisting his pennant; and if fresh out of the dock, and from the hands of the dock-yard officers, he proceeds immediately to prepare her for sea, by demanding her stores, provisions, guns, and ammunition, from the respective departments, according to her establishment. He enters such men as may volunteer and be fit for the service (in time of peace), or who may be sent to him from some rendezvous for raising men; and he gives them the several ratings of petty officers, leading seamen, able seamen, ordinary, or landsmen, as their apparent qualifications may entitle them to. If he be appointed to succeed the captain of a ship already in commission, he passes a receipt to the said captain for the ship's books, papers, and stores, and becomes responsible and accountable for the whole of the remaining stores and provisions; and, to enable him to keep the ship's accounts, he is allowed one or more clerks or clerks' assistants.

The duty of the captain of a ship, with regard to the several books and accounts, pay-books, entry, musters, dis-

Personnel. charges, &c., is regulated by various acts of Parliament; but the state of the internal discipline, the order, regularity, cleanliness, and the health of the crews, will depend mainly on himself and his officers. In all these respects the general printed orders for his guidance, contained in the present edition of the Queen's regulations and Admiralty instructions, prepared by Sir George Cockburn (aided by Mr Barrow), and issued to the fleet in 1844, are particularly precise and minute. And, for the information of the ship's company, he is directed to cause the articles of war, and abstracts of all acts of Parliament for the encouragement of seamen, and all such orders and regulations for discipline as may be established, to be hung up in some public part of the ship, to which the men may at all times have access. He is also to direct that they be read to the ship's company, all the officers being present, once at least in every month. In every ship where there is a chaplain, he is desired to be particularly careful that the attention and respect due to his sacred office be shown to him by all the officers and men, and that divine service be performed, and a sermon preached, every Sunday. He is not authorized to inflict any corporal punishment on any commissioned or warrant officer, but he may place them under arrest, and suspend any officer who shall misbehave, until an opportunity shall offer of trying such officer by a court-martial. He is enjoined to be very careful not to suffer the inferior officers or men to be treated with cruelty and oppression by their superiors. He alone is to order punishment to be inflicted, which he is never to do without sufficient cause, nor ever with greater severity than the offence may really deserve, nor until twenty-four hours after the crime has been committed, which must be specified in the warrant ordering the punishment; and all the officers and the whole ship's company are to be present at every punishment, which must be inserted in the log-book, and an abstract at the end of every quarter made out and sent to the Admiralty; a regulation which has been attended with infinite benefit to the strict and just discipline of the naval service. The greatest number of lashes he can inflict is 48. The total abolition of flogging, so often advocated, can never, in the opinion of any officer, be advantageously carried into effect; but it would seem desirable to reduce the number of lashes to 24, considering the extreme severity of the punishment and pain inflicted, which often renders the man totally unfit for duty for some days. The disgrace attending the punishment is more likely to deter others than the pain inflicted. In a few well-regulated ships corporal punishments are quite unknown during the whole period of their commission. It was never found necessary in any ship employed in the Arctic squadron, owing to the great regularity observed on board, to daily prayers being read, and to there being little or no drunkenness. With a view to checking the flogging in the navy, a return is annually called for by Parliament, and a column inserted showing the number of lashes sentenced, and the numbers inflicted, together with the highest number of lashes given in any one case, and the lowest, together with a sum total.

Lieutenant. The lieutenants take the watch by turns, and are at such times intrusted, in the absence of the captain, with the command of the ship. The one on duty is to inform the captain of all occurrences which take place during his watch; as strange sails that may be in sight, signals from other ships in company, change of wind, &c. He is to see that the ship be properly steered, the log hove, and the course and distance entered on the log-board; and, in short, he is to see that the whole of the duties of the ship are carried on with the same punctuality as if the captain himself were present. In the absence of the captain, the senior lieutenant is responsible for everything done on board.

Master. The master receives his orders from the captain or any of the lieutenants. His more immediate duties are those of stowing the ship's hold, and of attending to her sailing qualities; of receiving and placing the provisions in the ship, so as most conveniently to come at those which may be wanted. He is to take care that the cables are properly coiled in the tiers. The keys of the spirit-room are in his custody, and he is directed to intrust them only to the master's assistants. He has the charge of the store-rooms of the warrant-officers, which he is ordered frequently to visit; in short, the whole of the ship's provisions, water, fuel, and stores of every description, are under the superintendence of the master; and he is also intrusted, under the command of the captain, with the charge of navigating the ship, bringing her to anchor, ascertaining the latitude and longitude of her place at sea, surveying harbours, and making such nautical remarks and observations as may be useful and interesting to navigation in general. He keeps the ship's log-book and remark-book. For distinguished conduct masters are eligible for promotion to the rank of lieutenant; but few would accept it, except with a certain prospect of rising to the higher grades, of which there are instances. Personnel.

The warrant-officers are charged with the duty of receiving on board from the dockyards, and examining, the various stores of their respective departments, and keeping an account of the expenditure of them.

Gunner. The gunner has the charge of the ship's artillery and of the powder magazine. He is to see that the locks and carriages are kept in good order, and that the powder is preserved from damp; he is frequently to examine the musketry and small arms, and to see that they are kept clean and fit for service; and, in preparing for battle, it is his duty to take care that all the quarters are supplied with everything necessary for the service of the guns, and, during the action, that there be no want of ammunition served out. He is frequently to exercise the men at the guns, and to see that they perform this part of their duty with correctness, explaining and enforcing the necessity of their pointing the guns before they fire them, sponging them well, and close-stopping the touch-hole immediately after firing. The armourer and his mates are under the immediate orders of the gunner in everything that relates to the great guns and small arms.

Boatswain. The boatswain is charged with the duty of receiving and examining all the stores belonging to his department, consisting chiefly of the ropes and rigging, the latter of which he is ordered to inspect daily, in order that any part of it chafed or likely to give way may be repaired without loss of time. He is always required to be on deck at such times as all hands are employed; he is bound to see that the men, when called, move quickly upon deck, and when there, that they perform their duty with alacrity, and without noise or confusion. The sailmaker and the ropemaker are under his immediate orders.

Carpenter. The carpenter, when appointed to a ship, is carefully to inspect the state of the masts and the yards, whether in the dockyard or on board of the ship, to see that they are perfectly sound and in good order. He is to examine every part of the ship's hull, magazine, store-rooms, and cabins. He is every day when at sea carefully to examine into the state of the masts and yards, and to report to the officer of the watch if any appear to be sprung, or in any way defective. He is to see that the ports are secure and properly lined, and that the pumps are kept in good order, as also the boats, ladders, and gratings. The caulker is placed under his immediate orders, and he is to see that the former performs his duty in a workmanlike manner, in stopping immediately any leaks that may be discovered.

Engineer. The engineer, when first appointed to a steam-vessel, carefully examines the engines, paddles (or screw), and the boilers, and reports to the commanding officer any defects he discovers. He takes charge of all the engineers' stores and tools, and keeps account of receipts and expenditure.

Personnel. He is never to quit the engine-room during his watch, and visits it frequently at all times day and night. The leading stoker and stokers are under his immediate control.

Paymaster. The paymaster (formerly purser) has the charge of all the ship's provisions, and of the serving them out for the use of the crew. His charge is, therefore, of a most important matter; and, accordingly, he must not only produce good certificates of his conduct whilst serving in the capacity of clerk, but must also find two sureties for the due discharge of his trust, who are required to give bond in a penal sum, according to the rate or class of ship to which he may be appointed. The regulations and instructions for his guidance are minutely detailed in the general printed instructions, with all the various forms established for the keeping of his accounts with the accountant-general and comptroller of victualling, to whom he is immediately responsible. To assist him in the performance of his arduous duties, he is allowed to employ the clerk, with the sanction of the captain, who is responsible for the strict performance of the duties of all the officers under his orders, and acts, as it were, as a check on the paymaster in many parts of his duty, regarding the slop-books, muster-books, &c. He has also a steward under his immediate orders.

Other officers. The duties of the medical inspectors of hospitals and fleets, the surgeon of a ship and his assistants, the secretary to the commander-in-chief, the chaplain, the naval instructor, and inspectors of machinery afloat, are too obvious to require any specification.

Midshipmen and naval cadets. The midshipmen are considered as the principal petty officers, but have no specific duties assigned to them. In the smaller vessels, some of the senior ones are intrusted with the watch; they attend parties of men sent on shore; pass the word of command on board, and see that the orders of their superiors are carried into effect; in short, are exercised in all the duties of their profession, so as, after five years' service (eighteen months as cadet, and three years and six months as midshipmen), to qualify them to become lieutenants; and are then rated mates, provided they have passed the requisite examination, and are nineteen years of age.

Marines. Every ship, according to her class, has a certain number of marines as part of her complement. They are commanded by a captain or brevet-major, in from first to fourth rates inclusive, with three or two subalterns under them, and an established number of non-commissioned officers; but the party on board fifth rates and under is commanded by a subaltern, and in small vessels by a sergeant or corporal.

All marine officers, of whatsoever rank, when embarked, are to obey the orders of the captain or the commanding officer of the watch. The marines are exercised by their officers in the use of their arms; they are employed as sentinels, and in all other duties on board of which they are capable, with the exception of going aloft. The officer commanding has the charge of the arms, accoutrements, and drums; and he is to inspect, weekly at least, the state of the clothing of his party. The marines are in every respect treated as part of the ship's company.

Number of commissioned officers. The long continuance of the revolutionary war necessarily created a prodigious increase of the commissioned officers of the navy. Their numbers in the five following years of peace were,—

	1793.	1803.	1815.	1821.	1836.
Admirals	11	45	70	63	43
Vice-admirals	19	36	73	59	59
Rear-admirals	19	51	77	68	63
Captains	444	666	824	828	755
Commanders	160	410	762	776	823
Lieutenants	1408	2461	3211	3797	2976

Personnel. In the year 1857 there were on the active list of the navy 371 captains, 530 commanders, 1122 lieutenants; and on the retired and reserved list 129 captains, 243 commanders with rank of captain (besides 113 commanders on reserved half-pay), 254 lieutenants with rank of retired commanders (besides 618 on reserved half-pay). The total number of captains was therefore 743; commanders, 897; lieutenants, 1740; being a diminution of considerably upwards of 1000 officers of the foregoing ranks, as compared with the list in 1836.

The warrant-officers have increased from the average of about 400 in 1793 and 700 in 1821, to upwards of 1000 in 1857. They are divided into two classes,—viz., those who are fit for sea service, and those who are fit for harbour duty. The latter consist of about 150 gunners, boatswains, and carpenters. The total number of officers of the Royal Navy and Royal Marines in 1857 was upwards of 7300, excluding mates and midshipmen, clerks, warrant-officers, and engineers. These may be computed at 3000; making a grand total of 10,300 officers of all ranks.

The number of seamen and marines voted in 1792 was 16,000 (but never reduced to that number); in 1822 it was 21,000; in 1836, 32,000; 1840–1, 35,165; 1850–1, 39,000; 1853–4, 45,500; and in 1854–5, 48,000. The greatest number of seamen and marines voted in any one year during the French war was 150,000, and during the war with Russia, 76,000.

All officers of the navy wear a uniform, which is established in pursuance of the pleasure of the sovereign. It consists of blue cloth, with white collars and cuffs to the coats, and various embroidery and epaulets. The epaulets of the officers of the civil branch of the service are embroidered in gold and silver. The full dress, with cocked hats, is worn, on state occasions and at courts-martial, by all naval officers. The first naval uniform (blue and white) was established in 1748. The identical patterns then issued may now be seen in the United Service Institution. They were obtained a few years since from Plymouth, where they had been carefully preserved. In the reign of William IV. the facings were for a short time changed to red. The last alteration of the uniform was in 1856. The petty officers, seamen, and boys also wear certain regulated articles of dress; the former with marks of distinction on the left sleeve of their jackets. The seamen, too, wear good-conduct badges.

Ship's company. The crew of a ship of war consists of leading seamen, able seamen, ordinary seamen, landsmen, leading stokers, stokers, coal-trimmers, boys, and marines. The landsmen, boys, and marines, are always entered voluntarily, the latter in the same manner as soldiers, by enlisting into the corps, the two former at some rendezvous or on board particular ships. A supply of boys for the navy is also regularly sent from the Asylum at Greenwich and the Marine Society. Able and ordinary seamen also very commonly volunteer to serve during the war, and always in time of peace; but the high wages given by the merchant ships to seamen in time of war hold out such encouragement as to induce them to give the preference to that service, though in all other respects their treatment is far superior on board a Queen's ship, having better provisions, being subject to much less fatigue and exposure to the weather, well taken care of in sickness, and being entitled to pensions after twenty-one years' service, or when disabled. Indeed, the excellent regulations now rigidly adhered to on board H.M.'s ships, and the attention that is paid to the health and comfort of the crew, have overcome much of that reluctance which formerly was felt to the service of a ship of war.

Health of the crew. The state of health on board of a Queen's ship is, generally speaking, not exceeded in the most favoured spot on shore; and that horrible disease, the sea-scurvy, may now be considered as unknown in the British navy, since the universal

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introduction of lemon juice, or the citric acid, without an ample supply of which no ship is permitted to sail on a foreign voyage. It appears to have been known as a remedy for the scurvy, far superior to all others, two hundred years ago, but seems to have been utterly neglected, till Dr Lind, more than a hundred years afterwards, revived and stated clearly its singular powers. In 1600 Commodore Lancaster sailed from England with three other ships on the 2d of April, and arrived in Saldanha Bay on the 1st of August. The commodore's crew, having each had three table-spoonfuls of lemon juice every morning, arrived there in perfect health; whereas the other ships were so sickly, that they were unmanageable for want of hands. We have all felt the commiseration and horror which the perusal of the narrative of Anson's voyage produces. His ship, the Centurion, left England with 400 men, of whom 200 were surviving on his arrival at Juan Fernandez, and of these eight only were capable of duty, from scurvy. Yet even this horrible catastrophe seems to have failed in rousing the nation to have recourse to a remedy so certain and efficacious. Cook was well supplied with vinegar and other acids, and found the good effects of them; but the first general supply of lemon juice to the navy was established only in the year 1795, in consequence of a trial which had been made of it the preceding year in the Suffolk, of 74 guns. This ship left England, and arrived at Madras in September, without touching at any land. With every man's grog there were daily mixed two-thirds of a liquid ounce of lemon juice and two ounces of sugar. She lost not a man; and though the disease made its appearance in a few, an increased dose of lemon juice immediately removed it. Thus the Suffolk, after a voyage of 162 days, arrived without losing a man, or having a man sick of the scurvy; whereas the Centurion, in 143 days from the last place of her refreshment, lost half of her crew, whilst the other half were so feeble and emaciated as to be utterly helpless. Many instances not less remarkable might be mentioned.

The abundant supply of lime juice to the squadrons employed on Arctic service was the means of averting this dreadful malady, very few cases having occurred, except in the Investigator (Sir Robert M'Clure), after being four years in the ice. The issue of preserved meats and vegetables to all ships in the Royal Navy has also doubtless tended to the health of the crews.

Progressive diminution of sickness.

From the official returns collected by Sir Gilbert Blane, M. Dupin, a French author well versed in naval subjects, has drawn out the following table, which exhibits at one view the progressive diminution of sickness, death, and desertion in the British navy, calculated on 100,000 men :—

Years.	Sick sent to Hospital.	Deaths.	Desertions.
1779	40,815	2654	1424
1782	31,617	2222	993
1794	25,027	1164	662
1804	11,978	1606	214
1813	9,336	698	10

Hence it would appear, that the diminution of sickness and of deaths has been in the proportion of 4 to 1 nearly between the years 1799 and 1813. The diminution of desertions from the hospital in the same period is not the less remarkable; and it affords, at the same time, the strongest proof of the progressive amelioration of the condition of seamen on board British ships of war. Indeed, whether on board of ship, or in any of those noble institutions the naval hospitals, which are established at all the principal ports at home, and in the colonies abroad, the attention which is paid to the sick sailor is above all praise.

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The following returns, of more recent date, show the advance of medical science in this department :—

Years.	Sick Sent to Hospitals.	Dead in Hospitals.	Run from Hospitals.
1820	3,564	362	2
1830	3,137	187	2
1840	6,589	225	1
1850	9,743	309	...
1855	11,748	384	2

No wonder that 214 men should have run away from the doctors in 1804, when upwards of 1600 died in hospital out of 11,978. In 1855, out of the same number, there were only 384 deaths and 2 deserters. Can anything show more strongly the wonderful progress made in the medical department of the Royal Navy of late years?

Manning the fleet.

The speedy manning of the fleet, on the first breaking out of a war, is one of the most important objects that can devolve on the naval administration, as on it alone must depend the safety of our commerce and our colonies. This has been felt at all times; and accordingly a variety of schemes have been brought forward for this purpose, but all of them have heretofore failed of success, except the compulsory mode of raising men, under the authority of press-warrants, issued by the lords commissioners of the Admiralty, by virtue of the Queen's order in Council, renewed from year to year. On the occasion of the late war with Russia, however, the fleet was manned, for the first time, without recourse to impressment. There likewise issues, on the breaking out of a war, a proclamation from the sovereign, recalling all British seamen out of the service of foreign princes or states; and commanders of all ships of war are directed to search foreign vessels for such seamen.

Impressment.

The impressment of seafaring men, however anomalous under a free constitution like that of Great Britain, is defensible on state necessity, until it can be shown that the fleet, on an emergency, is capable of being manned without resorting to that measure. In consequence of some doubts being raised on the legality of the subject in the year 1676, when the affairs of the Admiralty were managed immediately under the direction of the King and the great officers of state, a discussion was held on this point, when it was decided by the judges and crown-lawyers, that the King had an indefeasible right to the services of his subjects when the state required them, and that the power of impressing seamen was indispensably inherent in the crown, without which the trade and safety of the nation could not be secured. The first instance of impressing men in Ireland seems to have been in the year 1678, when the lord-lieutenant received directions from the Privy Council to raise 1000 seamen for the fleet. In 1690 the lords-justices of Ireland were directed to assist the officers of the navy in impressing men in that kingdom. In 1697 a register was taken of all the seafaring men in Ireland, which amounted to 4424 men, of whom it is noted 2654 were Catholics. On several occasions, during Queen Anne's reign, the lords-justices of Ireland received directions to raise men to serve in the fleet.

In Scotland the mode of raising men by impressment was unknown before the Union; but in various instances the Council of Scotland was directed to raise volunteers for the fleet, each man to have 40s. as bounty.

In 1706 an experiment was tried for the speedy manning of the fleet, by virtue of an act of Parliament, which required the civil magistrates of all the counties to make diligent search for all seafaring men, and 20s. were allowed to the constables for each man taken up; the seamen to have pay from the day of delivery to the naval officers stationed to receive them; and if they deserted after that, they were to be considered as guilty of felony. By the same act, insolvent debtors, fit for the service, and

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In the same year, the Queen referred to the Prince of Denmark, then lord high admiral, an address from the House of Lords, relating to the three following points:—1*st*, The most effectual means for manning the fleet; 2*d*, The encouragement and increase of the number of seamen; 3*d*, The restoring and preserving the discipline of the navy. His Royal Highness submitted these points to such of the flag-officers and other commanders as could be assembled, who made a report, of which the substance was to the following effect:—1*st*, To cause a general register to be kept of all seafaring men in England and Ireland, for which they presented the draft of a bill; 2*d*, That all marines qualified to act as seamen should be discharged from the army, the officers to have levy money and the men's clothing returned; 3*d*, That not fewer than 20,000 seamen should be kept in employ in time of peace. But they observe, that as to restoring and preserving the discipline of the navy, no particular defect being specified, they could pronounce no opinion on that head.

Discipline. The discipline of the navy, or the government of Her Majesty's ships, vessels, and forces by sea, is regulated by the act 22d Geo. II., usually known by the name of the Articles of War. By this act, the lords commissioners of the Admiralty are empowered to order courts-martial for all offences mentioned therein, and committed by any person in and belonging to the fleet and in full pay; and also to delegate the same power to admirals commanding in chief on foreign stations, which power also may devolve on his successor in case of death or recall, provided that no commander-in-chief of any fleet or squadron, or detachment thereof, consisting of more than five ships, shall preside at any court-martial in foreign parts, the officer next in command being ordered to preside thereat.

Courts-martial. By this act no court-martial can consist of more than thirteen or of less than five persons, to be composed of such flag-officers, captains, or commanders, then and there present, as are next in seniority to the officer who presides at the court-martial. And when there are but three officers of the rank of captains, the president is to call in as many commanders under that rank as will make up five in all.

Articles of War. This code of laws for the government of the fleet consists of thirty-six articles, of which nine award the punishment of death, and eleven death or such other punishment as the court-martial shall deem the offence to deserve. Those which incur the former penalty are,—the holding illegal correspondence with an enemy; cowardice or neglect of duty in time of action; not pursuing the enemy; desertion to the enemy; making mutinous assemblies; striking a superior officer; burning magazines, vessels, &c., not belonging to an enemy; murder; sodomy. The penalty of death for cowardice, or other neglect of duty, in time of action (art. 12), and of not pursuing the enemy (art. 13), was, by the 19th George III., so far mitigated as to authorize the court-martial "to pronounce sentence of death, or to inflict such other punishment as the nature and degree of the offence shall be found to deserve." Under these articles thus mitigated, Admiral Byng would probably not have been condemned to death. The other eleven articles, which leave the punishment to the discretion of the court, are,—not preparing for fight, or not encouraging the men in time of action; suppression of any letter or message sent from an enemy; spies delivering letters, &c., from an enemy; relieving an enemy; disobedience of orders in time of action; discouraging the men on various pretences; not taking care of and defending ships under convoy; quarrelling with and disobeying a superior officer in the execution of his office; wilfully neglecting the steering of ships; sleeping on watch, and forsaking his station; robbery. The remaining sixteen articles incur the penalty of dismission from the service or from the ship, degradation of rank, or such other punishment as the court may judge the nature and degree of the offence to deserve. Personnel.

Queen's Regulations and Admiralty Instructions. The discipline of the navy is also maintained, and greatly depends upon the strict carrying out, on the part of the commanding officers, and the observance by all others, of the regulations and instructions issued from time to time by the lords of the Admiralty, under sanction of the Queen in Council, for the government of Her Majesty's forces at sea.

The first regular code of printed instructions would appear to be that known as the Duke of York's *Sailing and Fighting Instructions*, bearing date about 1660, which formed the basis of all the subsequent ones. There have been various editions from time to time; but by far the most comprehensive, while at the same time clear and as concise as the nature of the work would admit, is that now in use, which was prepared, as we have said, in 1844, with great skill and labour, by Admiral Sir George Cockburn, than whom there never was an officer before nor since so intimately acquainted with all the duties and professional details of the service, or more anxious for its welfare. In the compilation of this important and laborious work, known as the *Queen's Regulations and Admiralty Instructions*, he was assisted by Mr Barrow. Fourteen years have now elapsed, and it is quite time,—but unhappily Sir George Cockburn is no more,—that there should be a new edition brought out, embodying all the new orders and regulations, and consequent alterations and additions. There are upwards of 300 printed circulars alone, we believe, which have been subsequently issued, independently of written orders.

Petty punishment. Much, however, of the internal discipline of a ship of war depends upon the captain, who, being empowered to punish the men for minor offences, according to the usage of the service, courts-martial on seamen are rarely found necessary to be resorted to in well-regulated ships. In 1853 a more uniform system, defining the nature and duration of minor punishments, was promulgated by the Board of Admiralty. The principal circumstance which formerly militated against the perfect good order of the crew, was the great allowance of grog served out daily to the men, as established by order in Council, and which frequently led to drunkenness, and this again to insubordination. Perhaps half the punishments in the navy were, and still are, for this offence, which it requires the utmost vigilance and precautions on the part of the officers to prevent; but since the recent report of the committee of flag officers, which assembled in 1850, upon the question of the issue of spirits to the Royal Navy, and the diminution of the supply to one-half the quantity,—viz., from one gill to half a gill daily, with compensation-payment in money for the remainder,—the non-issue of raw spirits (the allowance of which is now mixed with three times its quantity of water), the stoppage of it altogether to boys of second class, and the issue of it at the discretion of the captain to boys of first class,—consequent upon the report of the committee,—there has been less drunkenness in the navy and less necessity for punishment. Great credit is mainly due to Admiral Sir James Deans Dundas, for his anxiety and humane exertions in endeavouring to suppress the punishment in the fleet. in which he has thus so happily succeeded.

The greatest desire has been evinced by many boards of Admiralty, of late years (more particularly those of Sir James Graham, the Earls of Minto, Haddington, and Auckland, and of Sir Francis Baring), to improve all branches of the service, and to render the Royal Navy as attractive as possible both to officers and men. One of the most material improvements is the attention which has been paid to the education both of boys and men. Seamen's libraries have been established on a large scale, and boys' schools; and rated ships

Personnel. have all got chaplains, naval instructors, and seamen's schoolmaster appointed to them. Why sloops and small vessels should be without one or the other it is not easy to comprehend. One thing, however, yet remains to be carried out, viz., daily prayers on board every ship in the service. They are read in a few well-regulated men-of-war on some stations, and were never omitted in any one of the ships engaged in the Arctic squadron. It is not too much to say, that owing principally to this, and to there being little or no opportunity for drunkenness, no corporal punishment was ever inflicted. The practice of daily prayers on board men-of-war is of ancient date, and the omission comparatively modern. In all the earlier editions of the regulations, till that of 1810, an order for daily service will be found.

Effects of discipline. In other respects the discipline of a well-organized ship of war is perfect; and to this discipline M. Dupin, a French writer of great sagacity, mainly ascribes the brilliant successes of the British navy, and to the want of it the ruin of that of France. "We have already cited," says he, "as a model, the management of the *matériel* of the English ships. In the preservation of this *matériel*, in the stowing it away, in the arrangement of whatever may be necessary either for manœuvres or for action, the most perfect regularity is observed. At the same time, what becoming austerity is maintained by the commanding officer; what obedience amongst the subalterns; and, in a space so limited, considering the number of men on board, and the multiplicity of movements they have to make in obeying so many different orders, what imposing silence! It is the calmness of strength, the presiding influence of wisdom. In the midst of the most complicated operations, and even in the heat and transport of battle, one hears only the words of command, pronounced and repeated from rank to rank, with a measured tone and perfect *sang froid*. No unseasonable advices, no murmurs, no tumult. The commanders meditate in silence; the word is given, and the men act without either speaking or thinking." This is remarkably so in the day of battle. Every officer and man knows precisely his place, and the duty he has to perform, on that day. By the general printed instructions, the captains of Her Majesty's ships are required to accustom the men to assemble at their proper quarters, to exercise them at the great guns, to teach them to point, fire, &c., under all circumstances of sea and weather. Indeed, it is well known that the preservation of the high character of the British navy essentially depends on the proper training of the seamen to the expert management of the guns, so as to be duly prepared in the day of battle, the issue of which so mainly depends on the cool, steady, and regular manner in which the ship's ordnance is loaded, pointed, and fired. Practice in these respects is much more necessary on board ships than on shore, as it can never happen that the ship is entirely steady, and has most frequently a rolling or pitching motion, for which allowances must be made, and which can only be made with effect by long practice.

Since 1830, when the Excellent was first established, much attention has been paid to the practice of gunnery in the Royal Navy; and all mates have to pass an examination on board that ship, which is stationed at Portsmouth for the practice of gunnery, where officers and men are instructed. They, too, pass examinations, and are appointed gunnery lieutenants and mates in the several seagoing ships; and the men are appointed seamen-gunners,—a rating of comparatively recent date. The training of seamen for landing in brigades with field-pieces has lately been adopted with great success.

Naval tactics. If the management of the great guns of a ship of war is more difficult than the artillery of a fort, so likewise are naval tactics more difficult than those of an army; inasmuch as there is more difficulty and less dependence in placing and directing the movements of an inanimate than an animate machine; although the recent introduction of auxiliary steam-engines in all the line-of-battle ships and frigates, and in many of the corvettes and sloops, has placed them under greater control. The general principles, however, are the same; the object of both being that of bringing the greatest possible force to bear on that point which is likely to produce the greatest possible injury to the enemy. With this view, as well as to keep a fleet together in compact order, so that straggling ships may not be cut off by the enemy, it has been found necessary to preserve a certain order of sailing, whether out of sight of an enemy or in his presence; and such an order as, according to the state of the wind and weather, and the point of bearing of the enemy's fleet, may most conveniently and expeditiously be changed into such a line of battle as the commander-in-chief may deem it most expedient to adopt in the attack to be made on his opponent. In order to do this, it is obvious that every individual captain must be able to know, under all circumstances, what the ship he commands will be able to do, in order to preserve her station in the fleet; for it is with ships as with horses, no two perhaps performing the same evolution with the same tightness of rein, or the same pressure of sail or steam. This shows the absolute necessity of a commander-in-chief frequently exercising his fleet in naval tactics, and to observe how such and such a ship will behave under a certain quantity of canvas and steam-power, and to assign her station in the line where she may appear calculated to act with the greatest efficiency. To facilitate these movements, the admirals commanding squadrons are considered as responsible for the movement of the ships in their respective divisions. They are to see that each captain strictly obeys the general order; and if any one is perceived to neglect his duty, whether belonging to his proper division or not, if in action, he has the power to send immediately another officer to suspend him. And in order that no confusion may arise, if, in time of battle, the admiral commanding in chief, or any of the admirals commanding squadrons, should be killed, his or their flags remain flying till the battle is decided. If the commander-in-chief be killed or severely wounded, a private signal is made to the second in command; or if a junior admiral be killed or wounded, the commander-in-chief is also acquainted by signal.

Steam tactics. Since the introduction of steam, the system of naval tactics has undergone a great change, and some well-planned, well-tried scheme of naval steam tactics is yet a desideratum. Admiral Moorsom was the first to turn attention to this subject. Happily no two steam fleets have hitherto been engaged in action, or brought into hostile collision; neither has there been any separate action with single steam-ships.

Code of naval signals. The silent method of communicating what is going on is the perfection of naval tactics; indeed it is very difficult to conceive how our ancestors contrived to manage a fleet without a code of signals. For great and important occasions, the exhibition of a flag or flags, in some particular part of the ship, might be generally understood to imply that the fleet should anchor, or tack, or form the order of sailing in two lines, or the line of battle, or some other great movement. The hoisting of a cask at the yard-arm might be understood to imply a want of water; or a hatchet, of wood; or an empty bag, of bread; and the table-cloth was a very significant invitation to dinner; but they had no means of interchanging freely their wants or intentions, or of conveying detailed intelligence. Even so late as the American war there was no established code of signals in the navy. "If an admiral," says Dr Beatson in his able *Memoirs*, "cannot command all the necessary movements of his ships by signal in the day of battle, he is not upon a footing with an enemy who possesses that advantage; and, even with better ships and better men, and more expe-

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rienced commanders, he may be foiled in his expectations of victory, if not defeated, from his want of means to direct and to perform the necessary evolutions of his fleet." "In no fight," he adds, "was the insufficiency of the present system of naval signals more conspicuous than in this (Keppel's unfortunate action); and it is to be hoped that if ever a new code be adopted for the use of the Royal Navy, it may be so clear and comprehensive, that such fatal errors as those which have been pointed out will in future be prevented." This, we may now say, has been accomplished on a plan of Sir Home Popham, which (together with Marryatt's) has rendered signals by flags as nearly perfect as they probably ever will be.

Boat signals.

Boat signals are also of the utmost importance; and the navy is indebted to Captain Wilmot for an admirable code which has recently been introduced by him, and is now in general use.

Improvement in navigation.

The encouragement afforded by government to every branch of science connected with the navy, and navigation in general, has been carried much farther by England than by any other European nation, and has produced the happiest results for commercial enterprise, by determining with accuracy the precise position of ships, by shortening long voyages, and by the discovery of new lands and unexplored regions. The name of Admiral Sir Francis Beaufort, who was for many years hydrographer of the Admiralty, and has recently departed this life, will ever hold a prominent position in the naval annals of England as one who, in his generation, rendered the utmost service, not only to his profession, but to the navy and marine of all nations, by the extreme care and accuracy with which the numerous charts published under his immediate superintendence have been issued to the world, embracing elaborate surveys in all parts of the globe. From the commencement of the eighteenth century, when a national reward was first offered to the man of science, or the artist, who should discover a method sufficiently exact to determine the longitude of a ship's place at sea, to the present time, the improvements in the construction and division of all kinds of instruments for measuring angles, in the calculations of lunar and other tables, and, above all, in the manufacture and adjustments of chronometers, have continued in gradual progression, and may now be considered as having arrived at such a degree of perfection, more especially the chronometers, that the discovery of the longitude can scarcely be said to remain a desideratum. We may form an idea what the progress in the improvement of chronometers has been, when a reward was offered by Parliament in the year 1814, to the first who should determine the longitude at sea *within a degree;* and in 1820, three chronometers, after remaining in the arctic regions for 18 months, returned to England without altering their rates more than a few seconds of time.

Personnel.

The officers of the Royal Navy are now much more generally versed in the sciences than they were in former years. In fact, it is now necessary for a young man to be well acquainted with a certain portion of mathematical and astronomical knowledge to enable him to pass an examination, without which he cannot be qualified for the commission of a lieutenant. Lord Auckland, desirous of encouraging a taste for scientific pursuits, caused a valuable scientific manual to be drawn up in the year 1847, and issued to the fleet. The examinations also of the several warrant-officers, and their qualifications for their respective stations, are more strictly attended to than formerly.

Pay and emoluments.

The encouragement given to the navy from its first regular establishment has marked it as a favourite service in the minds of the public. The sea-pay, the half-pay, and other emoluments, have generally been superior to those enjoyed by the army, but subject to great fluctuations in every reign, and to frequent changes in the same reign.

The following table will exhibit, at one view, the complete war establishment of officers and non-commissioned officers, seamen, and marines, on board every class of Her Majesty's ships, with the rate of pay now granted to each, as established by order in Council:—

Full Pay of the Royal Navy.

FLAG OFFICERS AND THEIR RETINUE.		Year.			Month of 31 Days.			Day.		
		L.	s.	d.	L.	s.	d.	L.	s.	d.
Admiral of the Fleet		2190	0	0	186	0	0	6	0	0
Admiral		1825	0	0	155	0	0	5	0	0
Vice-Admiral		1460	0	0	124	0	0	4	0	0
Rear-Admiral; Commodore of the First Class		1095	0	0	93	0	0	3	0	0
Table Money to all the above, in addition, when Commanding in Chief, and whilst their Flag is flying within the limits of their Station		1095	0	0	93	0	0	3	0	0
Captain of the Fleet. (For pay, see *Captains.*)										
Commodore of the Second Class, in addition to his Pay as Captain, if so ordered by the Admiralty	If Commanding in Chief	365	0	0	31	0	0	1	0	0
	If not Commanding in Chief	182	10	0	15	10	0	0	10	0
Flag-Lieutenant. (For pay, see *Lieutenants.*)										
Master of the Fleet. (For pay, see *Masters.*)										
Secretary	To the Admiral of the Fleet	500	7	1	38	7	8	1	7	5
	To a Flag Officer, Commander-in-Chief	401	10	0	30	16	0	1	2	0
	To all other Flag Officers and Commodores of the 1st Class	301	2	6	25	11	6	0	16	6
	To a Commodore of the 2d Class	150	11	3	12	15	9	0	8	3
Clerk to the Secretary	To a Commander-in-Chief	66	18	4	5	13	8	0	3	8
	To a Junior Flag Officer or Commodore of the 1st Class	54	15	0	4	13	0	0	3	0
Coxswain	To a Flag Officer	36	10	0	3	2	0	0	2	0
Steward, Cook, Domestic, Secretary's Servant	Ditto	24	6	8	2	1	4	0	1	10
COMMISSION OFFICERS.										
Captain of the Fleet		1095	0	0	93	0	0	3	0	0
Captain	1st Class. To the first 70, when employed	701	2	1	59	10	11	1	18	5
	2d Class. To the next 100, when employed	574	17	6	48	16	6	1	11	6
	3d Class. To all other Captains, when employed, below the first 170	450	3	4	38	4	8	1	4	8
Commander		301	2	6	25	11	6	0	16	6

COMMISSION OFFICERS—CONTINUED.	Year.	Month of 31 Days.	Day.
	L. s. d.	L. s. d.	L. s. d.
Lieutenant — In Command of any Ship or Tender other than those on the Packet or Surveying Establishment	200 15 0	17 1 0	0 11 0
Lieutenant — Of 7 years' standing in that rank, being, Senior of a sea-going rated Ship	200 15 0	17 1 0	0 11 0
Lieutenant — Of 7 years' standing in that rank, being, Ditto of a Flag Ship at the Home Ports	200 15 0	17 1 0	0 11 0
Lieutenant — Of 7 years' standing in that rank, being, Ditto of a rated Surveying Vessel, if he receive no additional Pay as Assistant Surveyor	200 15 0	17 1 0	0 11 0
Lieutenant — Of 7 years' standing in that rank, being, Ditto of a Troop Ship	200 15 0	17 1 0	0 11 0
Lieutenant — All others	182 10 0	15 10 0	0 10 0
Master — Of the Fleet	365 0 0	31 0 0	1 0 0
Master — 1st and 2d (if 20 Years' Service, &c.)	328 10 0	27 18 0	0 18 0
Master — " (if 15 Years' Service, &c.)	273 15 0	23 5 0	0 15 0
Master — Store Allowance when in Charge: 1st, 2d, and 3d Rates	73 0 0	6 4 0	0 4 0
Master — Store Allowance when in Charge: 4th, 5th, and 6th Rates	48 13 4	4 2 8	0 2 8
Master — Store Allowance when in Charge: Sloops, &c.	38 0 5	3 4 7	0 2 1
Master — In all other Ships: (If 10 Years' Service, &c.)	219 0 0	18 12 0	0 12 0
Master — In all other Ships: (If 6 Years' Service, &c.)	200 15 0	17 1 0	0 11 0
Master — In all other Ships: (Less than 6 Years' Service)	182 10 0	15 10 0	0 10 0
Chaplain — Above 10 Years' Service Afloat	200 15 0	17 1 0	0 11 0
Chaplain — Under 10 " " "	182 10 0	15 10 0	0 10 0
Chaplain — " 3 " " "	161 4 2	13 13 10	0 8 10
Ditto, in addition if acting as Naval Instructor — Above 10 Years' Service as Naval Instructor	136 17 6	11 12 6	0 7 6
Ditto — " 7 " " " "	115 11 8	9 16 4	0 6 4
Ditto — " 3 " " " "	104 18 9	8 18 3	0 5 9
Ditto — Under 3 " " " "	95 16 3	8 2 9	0 5 3
Ditto — Tuition allowance for each young Gentleman Instructed	5 0 0	0 8 5	0 0 3
Medical Inspector of Hospitals and Fleets — Above 5 Years' Service as such	766 10 0	65 2 0	2 2 0
Medical Inspector of Hospitals and Fleets — Under 5 Years' Service as such	574 17 6	48 16 6	1 11 6
Deputy Medical Inspector of Hospitals and Fleets	365 0 0	31 0 0	1 0 0
With such further allowance when employed in Hospitals on Shore, as their Lordships may think proper.			
Surgeon — If employed on the 1st July 1840, or on the completion of 3 Years' Service from 1st January 1838. Of an Hospital Ship	328 10 0	27 18 0	0 18 0
Surgeon — Above 20 Years' Full Pay Service, including Service as Assistant Surgeon	328 10 0	27 18 0	0 18 0
Surgeon — Above 10 Years' ditto	255 10 0	21 14 0	0 14 0
Surgeon — " 6 "	219 0 0	18 12 0	0 12 0
Surgeon — Under 6 "	200 15 0	17 1 0	0 11 0
Surgeon — If unemployed on the 1st July 1840, until the completion of 3 Years' Service from 1st January 1838. Above 20 Years' Full Pay Service, including 3 Years' service only as Assistant Surgeon	328 10 0	27 18 0	0 18 0
Surgeon — Above 10 Years' ditto	255 10 0	21 14 0	0 14 0
Surgeon — " 6 "	200 15 0	17 1 0	0 11 0
Surgeon — Under 6 "	182 10 0	15 10 0	0 10 0
Paymaster — 1st Class, 30 in number	680 14 7	57 6 5	1 12 11
Paymaster — 2d Class, 60 "	474 10 0	40 6 0	1 6 0
Paymaster — 3d Class, 80 "	319 15 10	29 14 2	0 19 2
Paymaster — 4th Class, 130 "	249 8 4	21 3 8	0 13 8
Assistant Paymaster in Charge	155 2 6	13 3 6	0 8 0
Assistant Paymaster, 1st Class	127 15 0	10 17 0	0 7 0
" 2d Class	91 5 0	7 15 0	0 5 0
Clerk	73 0 0	6 4 0	0 4 0
Assistant Clerk	46 12 6	3 17 6	0 2 6
Mate	66 18 4	5 13 8	0 3 8
Assistant Surgeon — In Ships in which no Surgeon is borne. Above 10 Years' Full Pay Service	184 0 5	15 12 7	0 10 1
Assistant Surgeon — Under 10 " "	165 15 5	14 1 7	0 9 1
Assistant Surgeon — In Ships in which a Surgeon is borne. Above 10 " "	174 17 11	14 17 1	0 9 7
Assistant Surgeon — " 3 " "	156 12 11	16 6 1	0 8 7
Assistant Surgeon — Under 3 " "	147 10 5	12 10 7	0 8 1
Second Master — In all Rates if qualified for Master	91 0 5	7 15 0	0 5 0
Second Master — If not qualified for Master, but above 4 Years' Full Pay Service	73 0 0	6 4 0	0 4 0
Second Master — If not qualified for Master, and under 4 Years' Service	66 18 4	5 13 8	0 3 8
Second Master — Store allowance when in Charge	27 7 6	2 6 6	0 1 6

If in ships bearing a Master, and from his absence or other cause, the stores should be placed under charge of a Second Master, the same store allowance is to be made to the latter as regulated for the former; or when a Second Master or other officer shall have charge of the stores in a tender, the Lords Commissioners of the Admiralty will decide, according to the circumstances of the case, whether any or what portion of the store allowance shall be granted to such officer.

SUBORDINATE AND WARRANT OFFICERS.

Naval Instructor — Above 10 Years' Service on Full Pay as such	182 10 6	15 10 0	0 10 0
Naval Instructor — " 7 " "	155 2 6	13 3 6	0 8 6
Naval Instructor — " 3 " "	136 17 6	11 12 6	0 7 6
Naval Instructor — Under 3 " "	127 15 0	10 17 6	0 7 0
Naval Instructor — Tuition allowance for each young Gentleman Instructed	5 0 0	0 8 5	0 0 3
Midshipman — In all Rates	31 18 9	2 14 3	0 1 9

SUBORDINATE AND WARRANT OFFICERS.			Year.	Month of 31 Days.	Day.
			L. s. d.	L. s. d.	L. s. d.
Master's Assistant	In all Rates		47 2 11	4 0 1	0 2 7
Naval Cadet	„		16 14 7	1 8 5	0 0 11
Gunner, Boatswain, Carpenter	Sea Pay	1st Class	120 2 11	10 4 1	0 6 7
		2d Class	103 8 4	8 15 8	0 5 8
		3d Class	86 13 9	7 7 3	0 4 9
	Tool Money to Carpenter on Sea Pay		4 11 3	0 7 9	0 0 3
	Harbour Service Pay	1st Class	101 17 11	8 13 1	0 5 7
		2d Class	79 1 8	6 14 4	0 4 4
		3d Class	63 17 6	5 8 6	0 3 6
Inspectors of Machinery and Chief Engineers	Inspectors of Machinery, when appointed to take charge of the Machinery of a Fleet or Squadron		365 0 0	31 0 0	1 0 0
	Inspectors of Machinery		328 10 0	27 18 0	0 18 0
	Chief Engineers above 20 Years' Service as Chief Engineers, if qualified for 1st or 2d rates		328 10 0	27 18 0	0 18 0
	Chief Engineers, 15 Years' Service as Chief Engineers, if qualified for 1st or 2d rates		282 17 6	24 0 6	0 15 6
	Chief Engineers, 10 Years' Service as Chief Engineers		237 5 0	20 3 0	0 13 0
	Chief Engineers, 6 Years' Service	„	209 17 6	17 16 6	0 11 6
	Chief Engineers, less than 6 Years' Service,	„	182 10 0	15 10 0	0 10 0
	Engineers qualified for Charge, with an increase of 1s. a day after 6 years' Sea Service as Engineers in Charge		182 10 0	15 10 0	0 10 0
Assistant Engineers (on New Establishment)	Sea Pay and when employed in Dockyards — Assistant Engineer	1st Class	158 3 4	13 8 8	0 8 8
		2d Class	126 4 7	10 14 5	0 6 11
		3d Class	106 9 2	9 0 10	0 5 10
	Harbour Service Pay — Assistant Engineer	1st Class	88 4 2	7 9 10	0 4 10
		2d Class	69 19 2	5 18 10	0 3 10
		3d Class	56 5 5	4 15 7	0 3 1

Table of Pay of Petty Officers, Seamen, and Boys, in the Royal Navy.

Rate of Pay for Men entering under the Old System, in all Rates.						RATINGS.				New Rate of Pay for Continuous-Service Men, in all Rates.					
31 Days.			Year.							31 Days.			Year.		
L.	s.	d.	L.	s.	d.					L.	s.	d.	L.	s.	d.
						Chief Petty Officers.									
3	2	0	36	10	0	Master at Arms, Chief Gunner's Mate, Chief Boatswain's Mate, Chief Captain of the Forecastle, Admiral's Coxswain, Chief Quarter Master, *Chief Carpenter's Mate				3	9	9	41	17	0
						Seamen's Schoolmaster				...			...		
						Ship's Steward :—	Day Pay.	Victualling store allowance.	Total per Diem.						
							s. d.	s. d.	s. d.						
						1st Rates	2 0	3 6	5 6	...			100	7	6
						2d Rates	2 0	3 0	5 0	...			91	5	0
						3d Rates	2 0	2 6	4 6	...			82	2	6
						4th Rates	2 0	2 0	4 0	...			73	0	0
						5th Rates	2 0	1 6	3 6	...			63	17	6
						6th Rates	20 1	1 1	3 1	...			56	5	5
						Sloops, &c., with a complement of 100 men and upwards	2 0	0 8	2 8	...			48	13	4
						Smaller vessels	2 0	0 4	2 4	...			42	11	8
						1st Class Working Petty Officers.									
2	14	3	31	18	9	Ship's Corporal, Gunner's Mate, Boatswain's Mate, Captain's Coxswain, Captain of the Forecastle, Quarter-Master, Coxswain of the Launch, Captain of the Main-Top, Captain of the Fore-Top, Captain of the Afterguard, Captain of the Hold				3	2	0	36	10	0

Rate of Pay for Men entering under the Old System, in all Rates.						RATINGS.	New Rate of Pay for Continuous-Service Men, in all Rates.					
31 Days.			Year.				31 Days.			Year.		
L.	s.	d.	L.	s.	d.		L.	s.	d.	L.	s.	d.
2	6	6	27	7	6	Leading Seaman	2	14	3	31	18	9
2	9	1	28	17	11	*Shipwright	2	16	10	33	9	2
2	3	11	25	17	1	Yeoman of the Store-Room, Second Captain of the Hold, Painter, Sailmaker's Crew, Blacksmith's Mate, Armourer's Crew, *Carpenter's Crew, †Cooper's Crew	2	11	8	30	8	4
2	14	3	31	18	9	Stoker and Coal Trimmer	3	2	0	36	10	0
2	1	4	24	6	8	Able Seaman	2	9	1	28	17	11

Rate of Pay for Men entering under the Old System, in all Rates.						RATINGS.	New Rate of Pay for Continuous-Service Men, in all Rat s.					
31 Days.			Year.				31 Days.			Year.		
L.	s.	d.	L.	s.	d.		L.	s.	d.	L.	s.	d.
3	2	0	36	10	0	*1st Class Working Petty Officers—Continued.* Sailmaker, Ropemaker, *Carpenter's Mate, *Caulker, Blacksmith, Leading Stoker	3	9	9	41	1	3
						2d Class Working Petty Officers.						
2	9	1	28	17	11	Coxswain of the Barge, Coxswain of the Pinnace, Captain of the Mast, Second Captain of the Forecastle, Second Captain of the Maintop, Second Captain of the Foretop, Yeoman of the Signals, Second Captain of the Afterguard, Captain of the Mizen-top	2	16	10	33	9	2
2	11	8	30	8	4	Sailmaker's Mate	2	19	5	34	19	7
2	9	1	28	17	11	Coxswain of the Cutter	2	16	10	33	9	2
2	11	8	30	8	4	†Cooper, Armourer, *Caulker's Mate	2	19	5	34	19	7
2	9	1	28	17	11	Musician, Head Krooman	...			...		

Personnel.

Table of Pay of Petty Officers, Seamen, and Boys, in the Royal Navy—Continued.

Personnel.

Rate of Pay for Men entering under the Old System, in all Rates. 31 Days.			Year.			RATINGS.	New Rate of Pay for Continuous-Service Men, in all Rates. 31 Days.			Year.		
L.	s.	d.	L.	s.	d.		L.	s.	d.	L.	s.	d.
2	6	6	27	7	6	Sick Berth Attendant						
						Bandman						
						Tailor						
						Butcher						
						Second Head Krooman						
						Flag Officer's and Superintendent's Domestics	...			...		
2	1	4	24	6	8	Captain's Steward						
						Captain's Cook						
						Ward, or Gun-Room Steward						
						Ward, or Gun-Room Cook						
						Secretary's Servant						

Rate of Pay for Men entering under the Old System, in all Rates. 31 Days.			Year.			RATINGS.	New Rate of Pay for Continuous-Service Men, in all Rates. 31 Days.			Year.		
L.	s.	d.	L.	s.	d.		L.	s.	d.	L.	s.	d.
2	1	4	24	6	8	Subordinate Officer's Steward						
						Subordinate Officer's Cook	...			...		
						Ship Steward's Assistant						
1	13	7	19	15	5	Ordinary Seaman	1	18	9	22	16	3
						Cook's Mate	...			...		
						Barber	...			...		
1	8	5	16	14	7	Second-Class Ordinary Seaman	1	11	0	18	5	0
						Commander's Servant	...			...		
						Kroomen	...			...		
0	18	1	10	12	11	Ship's Steward's Boy	...			...		
						Boy of the First Class	0	18	1	10	12	11
0	15	6	9	2	6	Boy of the Second Class	0	15	6	9	2	6

Seamen Gunners to receive 1d. a day in the 2d Class, and 2d. a day in the 1st Class, in addition to all other pay of their ratings.
Divers to receive 1d. a day in addition to all other pay of their ratings.
Men with these ratings (*), who have a complete set of tools, to receive 3d. a day for tool money, in addition to all other pay of their ratings.
Men with these ratings (†), who have a complete set of tools, to receive 2d. a day for tool money, in addition to all other pay of their ratings.
Seamen's Schoolmaster, Ship's Steward, Ship's Cook, Sick Berth Attendant, Servants, Musicians, Bandmen, Butchers, Barbers, Tailors, Ship Steward's Assistant, Cook's Mate, Kroomen, and Ship Steward's Boy, are not to be entered for continuous service.

Rate of Full Pay, Half Pay, and Retirement of Medical Officers serving in Hospitals, &c.

FULL PAY.	Per Diem. L.	s.	d.
Medical Inspector of Hospitals—			
On first appointment	1	13	0
After 5 years' service	2	2	0
Deputy Med. Inspect. of Hospitals, on appointment	1	7	6

FULL PAY.	Per Diem. L.	s.	d.
Surgeons of Hospitals—			
On appointment with less than 20 years' service	0	16	6
Above 20 years' service	1	0	6

SCALE of RETIREMENT for INSPECTORS, DEPUTY-INSPECTORS, &c., on the principle of allowing all Service to count in claims for Retirement, as recommended by the Naval and Military Commission.

ACTIVE SERVICE.	Retirement. Per Diem. L.	s.	d.	Per Annum. L.	s.	d.
Inspectors, from date of promotion to the rank (unless entitled to a higher rate by previous service)	0	17	6	319	7	6
,, after 20 years' service, including 3 years as Inspector of Hospitals	1	1	6	392	7	6
,, after 25 years' service	1	4	3	442	11	3
,, after 30 ,,	1	7	0	492	15	0
,, after 35 ,,	1	9	8	541	8	4
,, after 40 ,,	1	12	6	593	2	6

ACTIVE SERVICE.	Retirement. Per Diem. L.	s.	d.	Per Annum. L.	s.	d.
Deputy-Inspectors, from date of promotion to the rank (unless entitled to a higher rate by previous service	0	15	0	273	15	0
,, after 20 years' service, including 3 years as Deputy-Inspector	0	17	6	319	7	6
,, after 25 years' service	0	19	9	360	8	9
,, after 30 ,,	1	2	0	401	10	0
,, after 35 ,,	1	4	3	442	11	3
,, after 40 ,,	1	6	6	483	12	6

Pay of Royal Marines.

RANKS, &c.		Year. L.	s.	d.	Month of 31 Days. L.	s.	d.	Day. L.	s.	d.
First Colonel-Commandant		702	12	6	59	13	6	1	18	6
Second do.		365	0	0	31	0	0	1	0	0
Lieutenant-Colonel		310	5	0	26	7	0	0	17	0
Captain, having higher rank by Brevet		247	17	11	21	1	1	0	13	7
Captain		211	7	11	17	19	1	0	11	7
First Lieutenant	Above 7 years' service	136	17	6	11	12	6	0	7	6
	Under 7 years' service	118	12	6	10	1	6	0	6	6
Adjutant (in addition to his pay as First Lieutenant)		118	12	6	10	1	6	0	6	6
Quartermaster do. do.		85	3	4	7	4	8	0	4	8
Second Lieutenant		95	16	3	8	2	9	0	5	3
Cadet		66	18	4	5	13	8	0	3	8
Serjeant-Major		54	15	0	4	13	0	0	3	0
Colour-Serjeant		42	11	8	3	12	4	0	2	4
Quartermaster's Serjeant		45	12	6	3	17	6	0	2	6
Serjeant		33	9	2	2	16	10	0	1	10
Corporal	1st Class	27	7	6	2	6	6	0	1	6
	3d Class	24	6	8	2	1	4	0	1	4
*Fifer or Drummer		20	18	2¾	1	15	6¼	0	1	1¾
Private	1st Class	21	5	10	1	16	2	0	1	2
	3d Class	18	5	0	1	11	0	0	1	0
Good Conduct or Badge Pay	1 badge	1	10	5	0	2	7	0	0	1
	2 badges	3	0	10	0	5	2	0	0	2
	3 badges	4	11	3	0	7	9	0	0	3
	4 badges	6	1	8	0	10	4	0	0	4
	5 badges	7	12	1	0	12	11	0	0	5
	6 badges	9	2	6	0	15	6	0	0	6
Gratuities to Serjeants and Corporals. (See *Petty Officers.*)										

Personnel.

Pay of Royal Marine Artillery.

Personnel.

RANKS, &c.	YEAR.	MONTH OF 31 DAYS.	DAY.
	L. s. d.	L. s. d.	L. s. d.
Second Colonel-Commandant	479 1 3	40 13 9	1 6 3
Lieutenant-Colonel	326 19 7	27 15 5	0 17 11
Captain, having higher rank by Brevet	257 0 5	21 16 7	0 14 1
Captain	220 10 5	18 14 7	0 12 1
Captain superintending the Laboratory	220 10 5	18 14 7	0 12 1
First Lieutenant — Above 7 years' service	142 19 2	12 2 10	0 7 10
First Lieutenant — Under 7 years' service	124 14 2	10 11 10	0 6 10
Second Lieutenant	101 17 11	8 13 1	0 5 7
Serjeant-Major	74 18 0½	6 7 2¾	0 4 1½
Serjeant attending the Laboratory	63 17 6	5 8 6	0 3 6
Colour-Serjeant	53 12 2½	4 11 0¾	0 2 11½
Serjeant	44 9 8½	3 15 6¾	0 2 5½
Corporal — 1st Class	42 11 8	3 12 4	0 2 4
Corporal — 3d Class	39 10 10	3 7 2	0 2 2
Fifer or Drummer	26 4 8½	2 4 6¾	0 1 5½
Bombardier — 1st Class	39 10 10	3 7 2	0 2 2
Bombardier — 3d Class	36 10 0	3 2 0	0 2 0
Gunner — 1st Class	26 4 8½	2 4 6¾	0 1 5½
Gunner — 3d Class	23 3 10½	1 19 4¾	0 1 3½

N.B.—Corporals, Fifers, or Drummers, Bombardiers and Gunners, who obtain Good Conduct Badges, are allowed additional pay according to the regulated scale.

Establishment of half-pay.

Though the navy, as we have seen, was put upon a regular establishment under the reign of Henry VIII., neither officers nor seamen received any pay or emolument in time of peace until the reign of Charles II., when in 1668 certain allowances were made to flag-officers and their captains out of the L.200,000 a year voted for the whole naval service; and in 1674 certain other allowances were granted, by order in Council, to captains who had commanded ships of the first and second rates, and to the second captains to flag-officers, on the ground, as assigned in the preamble, that they had undergone the brunt of the war, without sharing in the incident advantages of it, as prizes, convoys, and such like, which the commanders of the smaller classes of ships had enjoyed. But the first regular establishment of half-pay for all flag-officers, captains, first-lieutenants, and masters, was by King William, in the year 1693, provided they had served a year in their respective qualities, or had been in a general engagement with the enemy. A regularly-established half-pay was further sanctioned by an order in Council of Queen Anne in 1700, the conditions of which were, that no officer should enjoy the benefit thereof who had absented himself without permission of the Lord High Admiral or lords commissioners of the Admiralty, or who had been dismissed for any misdemeanour, or by court-martial, or who had not behaved himself to the satisfaction of the Lord High Admiral, or who should have leisure to go out of his Majesty's dominions, if employed in the merchant service or otherwise, or who enjoyed the benefit of any public employment. Since the above period the rate of half-pay to the several officers of the navy has undergone various modifications. At present it stands thus:—

Rates of Half-Pay at present established for the Navy and Marines.

	Per Annum.	Per Diem.
FLAG OFFICERS.		
Admirals of the Fleet	L.1149 15 0	L.3 3 0
Admirals	766 10 0	2 2 0
Vice-Admirals	593 2 6	1 12 6
Rear ditto	456 5 0	1 5 0
Flag Officers on reserved half-pay	456 5 0	1 5 0
Retired Rear-Admirals (under order in Council of 1846)	456 5 0	1 5 0
CAPTAINS.		
To each of the first 70 as they stand on the active list of officers in seniority	L.264 12 6	L.0 14 6
To each of the next 100	228 2 6	0 12 6
To the rest	191 12 6	0 10 6
Retired (under order in Council of 1846)	365 0 0	1 0 0
Do. do.	328 10 0	0 18 0
*Retired Captain of 1840, and Aug. 1851	191 12 6	0 10 6
Reserved half-pay (order in Council, 25th June 1851)	191 12 6	0 10 6
COMMANDERS.		
To each of the first 150 in seniority on the active and reserved lists combined	L.182 10 0	L.0 10 0
To the remainder	155 2 6	0 8 6
Reserved half-pay (order in Council, 25th June 1851)	155 2 6	0 8 6
*Retired Commander of 1816	155 2 6	0 8 6
* Do. do. 1830	127 15 0	0 7 0
* Do. do. 1846 (*From the Master's List*)	228 2 6	0 12 6
* Do. do. do. (*do.*)	191 12 6	0 10 6
LIEUTENANTS.		
To each of the first 300 on the list in seniority on the active and reserved lists combined	L.127 15 0	L.0 7 0
To each of the next 700 do., do.	109 10 0	0 6 0
To the remainder	91 5 0	0 5 0

All lieutenants promoted to that rank after 1st July 1840 to receive 4s. a day, or L.73 per annum, to be increased to 5s. a day after three years' service as lieutenants in sea-going ships, and to advance by seniority to the rates of 6s. and 7s. a day; but may be placed on the 5s. list if, through illness contracted in the service, they shall have been unable to serve three years at sea in that rank.

	Per Annum.	Per Diem.
ROYAL MARINES.		
Colonels	L.264 12 6	L.0 14 6
Lieutenant-Colonels	200 15 0	0 11 0
Captains	127 15 0	0 7 0
First Lieutenants of 7 years' standing	82 2 6	0 4 6
The rest	73 0 0	0 4 0
Second Lieutenants	54 15 0	0 3 0
MASTERS.		
Above 20 years' service in the rank of Master, if qualified for 1st and 2d rates	L.237 5 0	L.0 13 0
Above 15 years' service in the rank of Master, if qualified for 1st and 2d rates	182 10 0	0 10 0
Above 10 years' service in the rank of Master	146 0 0	0 8 0
Above 5 do. do.	109 10 0	0 6 0
Under 5 do. do.	91 5 0	0 5 0
INSPECTORS OF MACHINERY AFLOAT AND CHIEF ENGINEERS.		
Above 20 years' service as Inspectors and Chief Engineers, or as Chief Engineers, if qualified for 1st or 2d rates	L.237 5 0	L.0 13 0
Above 15 years' service as Inspectors and Chief Engineers, or Chief Engineers, if qualified for 1st or 2d rates	182 10 0	0 10 0
Above 10 years' service as Inspectors and Chief Engineers, or as Chief Engineers	146 0 0	0 8 0
Above 5 years' service as Inspectors and Chief Engineers, or as Chief Engineers	109 10 0	0 6 0
Under 5 years' service as Inspectors and Chief Engineers, or as Chief Engineers	91 5 0	0 5 0

Personnel.

MEDICAL OFFICERS.

	Per Annum:	Per Diem.
Medical Inspectors of Hospitals and Fleets	L.319 7 6	L.0 17 6
After 5 years' service as such	383 5 0	1 1 0
Physicians—After 10 years' service	383 5 0	1 1 0
„ „ 3 years	273 15 0	0 15 0
Under that time	191 12 6	0 10 6
Deputy Medical Inspectors of Hospitals and Fleets from date of promotion, unless entitled to a higher rate by previous service	273 15 0	0 15 0
After 7 years' service as such	319 7 6	0 17 6

SURGEONS.

Surgeons	L.91 5 0	L.0 5 0
Above 6 years' service	109 10 0	0 6 0
„ 10 „	127 15 0	0 7 0
„ 15 „	146 0 0	0 8 0
„ 20 „	182 10 0	0 10 0
„ 25 „ (with leave to retire)	237 5 0	0 13 0
„ 30 „ do.	273 15 0	0 15 0

ASSISTANT-SURGEONS.

Assistant-Surgeons	L.36 10 0	L.0 2 0
Above 3 years' service	54 15 0	0 3 0
„ 10 „	82 2 6	0 4 6
„ 20 „	91 5 0	0 5 0
Dispensers	91 5 0	0 5 0

All medical officers below the rank of deputy medical inspector who may hereafter be appointed to hospitals, and who may be superseded or retire therefrom, shall, according to their respective ranks, receive the rate of half-pay to which they may be entitled according to length of service, all time included.

PAYMASTERS.

On the retired list	L.155 2 6	L.0 8 6
To each of the first 100	127 15 0	0 7 0
To each of the next 200	109 10 0	0 6 0
To the remainder	91 5 0	0 5 0

Such Paymasters as shall serve three years under the new system will receive half-pay at the following rates:—

If with 12 years' service as a Paymaster, 3 of which in a 1st or 2d rate	L.191 12 6	L.0 10 6
If with 9 years' service as Paymaster, 3 of which in a 3d or 4th rate	164 5 0	0 9 0
If with 6 years' service as Paymaster, 3 of which in a 5th or 6th rate	136 17 6	0 7 6
If with 3 years' service as Paymaster	109 10 0	0 6 0
To the remainder	91 5 0	0 5 0

RATES OF PENSION TO BE GRANTED TO INSPECTORS OF MACHINERY AFLOAT, AND TO ENGINEERS OF THE ROYAL NAVY.

(*Under Her Majesty's Order in Council of 13th June* 1853.)

To an inspector of machinery afloat, provided he shall have served upwards of five years in that rank, a pension of from L.160 to L.180 per annum.

If an inspector of machinery afloat be found unfit prior to completing five years' service in that rank, the time so served shall be added to his service as chief engineer, and he shall be pensioned on the scale for chief engineers.

To a chief engineer, having served twelve years as a chief engineer, and being in the first class, a pension of L.110 to L.130 per annum; having served six years as a chief engineer, and being in the first or second class, a pension of from L.85 to L.105 per annum; having served five years as an engineer in the Royal Navy, three of which as a chief engineer, a pension of from L.75 to L.90 per annum.

If a chief engineer be found unfit prior to completing three years in that rank, the time so served shall be added to his service as assistant-engineer, and he shall be pensioned on the scale for an assistant-engineer.

To an assistant-engineer, having served as such twenty years in the Royal Navy, and being in the first class, a pension of from L.65 to L.75 per annum; having served as such ten years in the Royal Navy, and being in the first or second class, a pension of from L.50 to L.60 per annum; having served as such three years in the Royal Navy, a pension of from L.40 to L.50 per annum.

The time served by assistant-engineers as engineers on the old establishment shall be reckoned as if the same had been served as assistant-engineers.

CHAPLAINS.

After 8 years' service at sea	L.91 5 0	L.0 5 0
After 10 „ „ *under New Regulations*	91 5 0	0 5 0
For each year's longer service than 8 at sea, 6d. per diem additional till it reach	182 10 0	0 10 0

CHAPLAINS AND NAVAL INSTRUCTORS.

After 15 years' service, one half of the highest rate of half-pay of naval instructors, in addition to the half-pay to which they may be entitled as chaplains.

NAVAL INSTRUCTORS.

After their first entry	L.36 10 0	L.0 2 0
After 3 years' service on full pay	54 15 0	0 3 0
„ 10 „ „	82 2 6	0 4 6
„ 15 „ „	91 5 0	0 5 0
„ 20 „ „	127 15 0	0 7 0

(*Payable Quarterly.*)

SECRETARIES.

	Per Annum.	Per Diem.
After 12 years' actual service as Secretaries	L.219 0 0	L.0 12 0

Personnel.

MATES.

2s. 6d. a day, or L.45, 12s. 6d. per annum, after three years' actual sea service as mates, and when unable to obtain employment in Her Majesty's service, provided their conduct during service shall have been satisfactory, and provided they do not decline or avoid service when called upon.

The lords commissioners of the Admiralty are empowered to allow any mate to retire from the service, with a pension of 2s. 6d. a day, after twenty years' actual service, during ten years of which he must have held the rating of mate.

SECOND MASTERS.

2s. 6d. a day, or L.45, 12s. 6d. per annum, after three years' sea service as second masters, provided they cannot obtain employment in the navy, and do not decline or avoid service when it is offered to them.

The period of three years' service may be dispensed with in the case of officers who shall have been invalided for sickness or injuries caused by the service, and which shall render them permanently disqualified for further employment.

In no case will half-pay be allowed to second masters unless the conduct of the officer whilst serving shall have been in all respects satisfactory.

ASSISTANT PAYMASTERS—*as Mates.*

The boatswains, gunners, and carpenters of the navy have pensions or superannuations, in lieu of half-pay, according to the following scale, formed on a consideration of the total length of service as warrant officers, with the length of service in commission.

Total Service.	Commis. Service.	Pension.	Total Service.	Commis. Service.	Pension.
30 yrs.	20 yrs.	L.85	20 yrs.	5 yrs.	L.45
30	15	75	15	15	60
30	10	65	15	10	50
30	5	55	15	5	40
20	20	75	10	10	45
20	15	65	10	5	35
20	10	55			

Prize money.

By proclamation, bearing date 9th March 1854, the following regulations were adopted for the distribution of prize money, viz.:—

The flag-officer or officers shall have one-twentieth part of the whole net proceeds arising from prizes captured from the enemy by any of the ships or vessels under his or their command, and of the rewards conferred for the same, according to the following conditions and modifications, save and except as hereinafter provided and directed; that is to say:—

When there is but one flag-officer he shall have the entire one-twentieth part; when two flag-officers shall be sharing together, the chief shall have two-thirds, and the other flag-officer shall have the remaining one-third of the one-twentieth part; and when there shall be more than two flag-officers, the chief shall have one-half of the said one-twentieth part, and the remaining half shall be equally divided among the junior flag-officers; commodores of the first class and captains of the fleet to share as flag-officers: Provided always, That no flag-officer, unless actually on board any ship or vessels of war, and at the actual taking, sinking, burning, or otherwise destroying any ship or ships of war, privateer or privateers, belonging to the enemy, shall share in the distribution of any head money or bounty money granted as a reward for taking, sinking, burning, or otherwise destroying any such ship or vessel of the enemy.

No flag-officer commanding in any port in the United Kingdom shall share in the proceeds of any prize captured from the enemy by any ship or vessel which shall sail from or leave such port by order of the Lord High Admiral, or of the commissioners for executing the office of Lord High Admiral.

When ships or vessels under the command of several flag-officers belonging to separate stations shall be joint captors, each flag-officer shall receive a proportion of the one-twentieth part, according to the number of officers and men present under the command of each such flag-officer; and when any ship or vessel under orders from the Lord High Admiral, or from the commissioners for executing the office of Lord High Admiral, are joint captors with other ships or

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vessels under a flag or flags, the like regulations as to the apportionment of the flag share to the flag-officer or officers are to be observed.

With reference to flag-officers it is to be noted:—

That when an inferior flag-officer is sent to reinforce a superior officer on any station, the superior flag-officer shall not share in any prize taken by the inferior flag-officer before he has arrived within the limits of that station, unless the inferior officer shall have received some order directly from, and shall be acting in execution of, some order issued by, such superior flag-officer.

No chief flag-officer quitting any station, except upon some definite urgent service, and with the intention of returning to the station as soon as such service is performed, shall share in any prize taken by H.M.'s ships or vessels left behind after he has passed the limits of the station, or after he has surrendered the command to another flag-officer appointed by the Admiralty to command in chief upon such station.

An inferior flag-officer quitting any station (except when detached by orders from his commander-in-chief upon a special service, accompanied with orders to return to such station as soon as the service has been performed) shall have no share in prizes taken by the ships and vessels remaining on the station after he has passed the limits thereof.

In like manner flag-officers remaining on such station shall not share in the prizes taken by such inferior officer, or by ships or vessels under his immediate command, after he has quitted the limits of the station, except he has been detached as aforesaid.

A commander-in-chief or other flag-officer belonging to any station shall not share in any prize or prizes taken out of the limits of that station by any ship or vessel under the command of a flag-officer of any other station, or under orders from the commissioners of the Admiralty, unless such commander-in-chief or flag-officer is expressly authorized by the said commissioners to take the command of that station in which the prize or prizes is or are taken, and shall actually have taken upon him such command.

Every commodore having a captain under him shall be esteemed a flag-officer with respect to the twentieth part of prizes taken, whether he be commanding in chief or serving under command.

The first captain to the admiral and commander-in-chief of the fleet, and also the first captain to any flag-officer appointed to command a fleet of ten ships of the line or upwards, shall be deemed to be a flag-officer for the purpose of sharing in prize, and shall be entitled to share therein as the junior flag-officer of such fleet.

Any officer on board any ships of war at the time of capturing any prize or prizes who shall have more commissions than one, shall be entitled only to share in such prize or prizes according to the share allotted to him by the above-mentioned distribution, in respect to his superior commission or office.

And with reference to other officers it is to be noted,—

That a captain, commander, or other commanding officer of a ship or vessel, shall be deemed to be under the command of a flag when he shall have received some order from, or be acting in the execution of some order issued by, a flag-officer, whether he be or be not within the limits of the station of such flag-officer; and in the event of his being directed to join a flag-officer on any station, he shall be deemed to be under the command of such flag-officer from the time when he arrives within the limits of the station, which circumstance is always to be carefully noted in the log-book; and it shall be considered that he continues under the flag-officer of such station until he shall have received some order directly from, or be acting in the execution of some order issued by some other flag-officer, duly authorized, or by the Lord High Admiral, or the commissioners for executing the office of Lord High Admiral

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The captain, commander, lieutenant commanding, master commanding, or any other officer duly commanding, any ship, sloop, or vessel of war, singly taking any prize from the enemy,—that is to say, the officer actually in command at the time,—shall have one-eighth of the remainder, or if there is no flag, one-eighth of the entire net proceeds; except that, if the single capturing ship be a rated ship, having a commander under the captain, the commander shall take a portion of the one-eighth part, as if he were commander of a sloop, according to the proportion hereinafter set forth; and if more than one commanding officer of the same rank of command shall be entitled to share as joint captors, the one-eighth shall be equally divided between them; but when captains, commanders, lieutenants commanding, and masters commanding, respectively, H.M.'s ships and vessels of war, and commanders under captains in rated ships, shall share together, in whatever variety of combination, the one-eighth shall be so divided into parts for a graduated apportionment as to provide for each captain receiving six parts, each commander of a sloop, or commander under a captain in a rated ship, three parts, and each lieutenant commanding, or master commanding, or other officer actually commanding, a small vessel of war, two parts; commodores of the second class, and field-officers of marines, or of land forces serving as marines, doing duty as field officers, above the rank of major, to share as captains; and field officers of marines, or of land forces serving as marines, and doing duty in the rank of major, to share as commanders of sloops.

After provision shall thus have been made for the flag share (if any), and for the portion of the commanding officer or officers, and others as above specified, the remainder of the net proceeds shall be distributed in ten classes, so that each officer, man, and boy, composing the rest of the complements of H.M.'s ships, sloops, and vessels of war, and actually on board at the time of any such capture, and every person present and assisting, shall receive shares, or a share, according to his class, as set forth in the following scale:—

First Class.—Master of the fleet, inspector of steam machinery afloat, when embarked with a fleet, medical inspector, or deputy medical inspector, when embarked with a fleet, forty-five shares each.

Second Class.—Senior lieutenant of a rated ship, not bearing a commander under the captain, secretary to the admiral of the fleet, or admiral commanding in chief, thirty-five shares each.

Third Class.—Sea lieutenant, master, captain of marines, of marine artillery, or of land forces doing duty as marines, whether having higher brevet rank or not, secretary to an admiral or to a commodore of the first class not commanding in chief, chief engineer, twenty-eight shares each.

Fourth Class.—Lieutenant or quarter-master of marines, lieutenant of marine artillery, lieutenant, quartermaster, or ensign of land forces doing duty as marines, secretary to a commodore of the second class, chaplain, surgeon, paymaster, naval instructor, mate, assistant-surgeon, second master, assistant-paymaster in charge, assistant-engineer, gunner, boatswain, carpenter, eighteen shares each.

Fifth Class.—Midshipman, master's assistant, pilot, clerk (not passed), master-at-arms, chief gunner's mate, chief boatswain's mate, chief carpenter's mate, chief captain of the forecastle, admiral's coxswain, chief quartermaster, seamen's schoolmaster, ship's steward, ship's cook, ten shares each.

Sixth Class.—Naval cadet, clerk's assistant, captain's coxswain, ship's corporal, quartermaster, gunner's mate, boatswain's mate, captain of the forecastle, captain of the after-guard, captain of the hold, captain of the maintop, captain of the foretop, coxswain of the launch, sailmaker, ropemaker, caulker, leading stoker, blacksmith, serjeant of marines, of marine artillery, or of land forces doing duty as marines, nine shares each.

Seventh Class.—Captain of the mast, captain of the

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mizen-top, yeoman of the signals, coxswain of the barge, coxswain of the pinnace, coxswain of the cutter, second captain of the forecastle, second captain of the maintop, second captain of the foretop, second captain of the afterguard, sail-maker's mate, caulker's mate, musician, cooper, armourer, corporal of marines or of land forces doing duty as marines, bombardier of marine artillery, head krooman, six shares each.

Eighth Class.—Leading seaman, shipwright, second captain of the hold, able seaman, carpenter's crew, sailmaker's crew, cooper's crew, armourer's crew, yeoman of the store-rooms, steward's assistant, ordinary seaman, blacksmith's mate, private and fifer of marines, or of land forces doing duty as marines, gunner of marine artillery, painter, stoker, coal trimmer, second head krooman, sick-berth attendant, bandsman, tailor, butcher, three shares each.

Ninth Class.—Cook's mate, ship's steward's boy, admiral's domestic, superintendent's domestic, admiral's steward and cook, captain's steward and cook, ward-room and gun-room steward and cook, subordinate officer's steward and cook, commander's servant, secretary's servant; second class ordinary seaman, assistant stoker, barber, boy of the first class, first and second class krooman, supernumeraries, except as hereinafter provided, persons borne merely as passengers, and not declining to render assistance on occasion of capture, two shares each.

Tenth Class.—Boy below the first class, one share.

All supernumeraries holding ranks in the service above the ranks or ratings specified in the fifth class, who have been ordered to do duty in any of H.M.'s ships or vessels by the Lord High Admiral, or by the commissioners for executing the office of Lord High Admiral, by the senior officer of the fleet or squadron; or, if none senior, then by the captain or commanding officer of the capturing ship or vessel, if not by special authority employed in higher capacities, shall share according to the rank which they respectively hold in the service; but in all cases to qualify them for so sharing, and not merely as supernumeraries in the ninth class, due notation of their being thus respectively ordered to do duty must have been made on the muster-books.

With respect to supernumeraries of ratings in the service below the denominations of those specified in the fourth class, who, at full victuals, are engaged in the ordinary duties of the ship, they shall share according to their ratings.

When any capture is made from the enemy, the captains or commanding officers of H.M.'s ships or vessels of war making the same shall transmit, or cause to be transmitted, as soon as may be, to the secretary of the Admiralty a true and perfect list of all the officers, seamen, marines, soldiers, and others, who were actually on board on the occasion, accompanied by a separate list, containing the names of those belonging to the crew who were absent on duty or otherwise at the time, specifying the cause of such absence, each list to contain the quality of the service of each person.

Conveyance of Treasure.—Scale of Rates.

	For Crown Treasure.	For Treasure belonging to other Parties. Peace and War.	
		Gold or Jewels.	Silver.
	Per cent.	Per cent.	Per cent.
Between any two ports, the navigable distance between which shall not exceed six hundred leagues	¾	¾	1
Between any two ports, the navigable distance between which shall exceed six hundred leagues, and shall be less than two thousand leagues	1	1¼	1¼
For any distance of two thousand leagues and upwards	1	1¼	2

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The above rates are payable clear of all deduction whatsoever; and it is to be stipulated in the bill of lading that the captains and commanding officers of H.M.'s ships and vessels shall not be liable to any expenses attending the shipment of such treasure, or other articles, until the same shall be safe alongside of their respective ships or vessels, and that their liability shall cease from the moment they shall have landed the treasure at the port to which the ships carrying the treasure shall be destined.

Honours and rewards.

Another great encouragement for young men to enter the naval service arises from the honours bestowed by the sovereign for any brilliant exploit. Thus, in consequence of the skill and bravery which were exhibited in the great and glorious action of the 1st of June 1794, his Majesty was graciously pleased to confer on Earl Howe the order of the garter; Admirals Graves and Sir Alexander Hood were made barons of the kingdom of Ireland; and Rear-admirals Bowyer, Gardner, and Pasley, together with Sir Roger Curtis, captain of the Queen Charlotte, were created baronets. Gold medals and chains were also distributed to such admirals, and gold medals to such captains, as were particularized in Lord Howe's despatches. The first lieutenants of each ship were promoted to the rank of commanders; and pensions of L.1000 per annum were granted to Rear-admirals Bowyer and Pasley, in consideration of the loss of limbs.

For the action of the 14th of February 1797, Lord St Vincent was advanced to the dignity of an earl, and a pension was granted to him of L.3000 a-year; Vice-admirals Thompson and Parker were created baronets; Commodore Nelson received the order of the bath, and Captain Calder of the Victory the honour of knighthood; and gold medals were distributed to the admirals and captains.

For the action of the 11th of October 1797, Admiral Duncan was created a viscount, with a pension of L.2000 a-year; Vice-admiral Onslow was made a baronet; and Captain Fairfax had the honour of knighthood. Gold medals were also distributed to the admirals and captains.

For the action of the 1st of August 1798, his Majesty was pleased to testify his sense of the importance of this brilliant achievement by raising Sir Horatio Nelson to the dignity of the peerage, by the title of Baron Nelson of the Nile, and by directing medals to be distributed to the captains. The first lieutenant of the Majestic was made a captain, and the first lieutenants of the other ships were promoted to the rank of commanders; and for the attack of the Danish fleet at Copenhagen, Lord Nelson was raised to the dignity of a viscount, and the order of the bath was conferred on Admiral Graves.

For the ever memorable action of Trafalgar, in which Lord Nelson fell in the arms of victory, his Majesty was pleased to confer upon his brother the rank of earl, with a pension of L.5000 a-year, and the sum of L.120,000 was voted by Parliament for the purchase of an estate to be annexed to the title; Admiral Collingwood was raised to the dignity of baron, Lord Northesk was honoured with the order of the bath, and Captain Hardy was created a baronet; the captains received medals, five lieutenants were made captains, and twenty-four commanders; twenty-two midshipmen were made lieutenants, and the senior captain of marines was made brevet-major.

By this last act of Lord Nelson's life was annihilated the only remaining hope of the combined navies of France and Spain, and a blow given to the naval power of the enemies of Great Britain, which they never recovered during the remainder of the war.

In the secondary victories of Sir John Warren, Sir John Duckworth, Sir Robert Calder, Sir Richard Strachan, Lord Gambier, and Lord Exmouth, and even for brilliant actions of single ships, appropriate distinctions have never been with-

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held. Exclusive of peerages and baronetcies, the honours bestowed for gallant conduct in the naval service at present consist of six knights grand crosses of the military Order of the Bath, thirty-three knights commanders, and 114 companions of the Bath. In addition to these, there are of the civil Order of the Bath one cross, two knights commanders, and three companions.

Medals have also been granted of late years by the Queen for various naval services, and distributed alike to the officers, seamen, and marines. These consist of the war medal for actions in ships and boats from 1793 to 1815; the medal for Algiers, Navarino, Acre, and Syria; the Burmese, China, and Kafir medal; and, lastly, the medal for services performed in the Arctic seas, which have greatly added to the renown of the British navy, have led to vast discoveries in that interesting portion of the globe, solving the problem of the N.W. passage, which for three centuries engaged the attention of the maritime nations of Europe, and rendering illustrious the names of many officers. Conspicuous among these in our naval annals will ever stand the names of Franklin, Parry, Ross, Collinson, and M'Clure, while those of Scoresby and Penny will be scarcely less conspicuous in the mercantile marine. The institution of the Order of Valour will be another incentive to the officers and men of the Royal Navy in the performance of heroic deeds in their country's service. There are at present twenty-five officers, seamen, and marines, recipients of the Victoria Cross. In addition to the foregoing there are many officers and seamen authorized to wear foreign orders—the Legion of Honour, the Royal Hanoverian Guelphic Order, the orders of St Michael, St George, the Tower and Sword, Redeemer of Greece, the Medjedic, &c.

Naval aides-de-camp to the Queen.

Amongst the honours bestowed by the sovereign upon officers of the navy and Royal Marines is the appointment of aides-de-camp to the Queen. Of these there are twelve: one of them, the first and principal, is an admiral, ten are captains, and two colonels of marines.

Good-service pensions.

Good-service pensions are also awarded to a certain number of flag-officers, captains, and field-officers of marines. These are selected according to their standing, length and nature of services, a statement of which is given, in each case, in the annual naval estimates presented to Parliament. There are at present seven flag-officers and twenty-one captains of the Royal Navy, and three field-officers of the Marines, in receipt of the good-service pension.

Pensions for wounds.

The provision which is made for officers, in the event of losing a limb, or being so severely wounded in the service that the prejudice to the habit of body is equal to the loss of a limb, is another encouragement for entering the naval service. There are at present 173 officers to whom pensions for wounds have been granted.

For an admiral, from L.300 to L.700 per annum.					
A captain, wounds	250	0	; loss of a limb,	L.300	0
Commander	150	0	;	200	0
Lieutenant	91	5	;	91	5
Marine officers the same as in the army.					

Widows' pensions.

A provision is likewise made for the widows of the commission and warrant officers of the royal navy, and voted annually on the navy estimates. The pensions are allowed according to the annexed scale, being similar, in most cases, to the widows of officers in the army of corresponding ranks. The latter are also provided for by an annual vote of Parliament.

Rules and Orders for granting Pensions to the Widows of Commission and Warrant Officers of the Royal Navy.

Art. 1.—Widows of commission and warrant officers of the Royal Navy may be allowed pensions as hereinafter directed, and subject to the following restrictions, provided they shall appear to the lords commissioners of the Admiralty to be proper and deserving objects of the public bounty, and not left in wealthy circumstances.

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Art. 2.—The rates of pensions shall be as follows, viz.:—

Rank of Officer.	Widow's Ordinary Pension.	Special Pension in lieu of Ordinary Pension.*	Special Pension in lieu of Ordinary Pension.†
	L.	L.	L.
Flag officers.....	120	According to circumstances.	According to circumstances.
Captains retired under O. C. 1846.....	110	...	...
Captains of 3 years standing and upwards	90	200	150
Captains under 3 years standing.....	80	200	140
Captains retired under O. C. 1840.....	75	...	...
Commanders.....	70	120	100
Commanders retired under O. C. of 1846...	60	...	...
Commanders retired under O. C. of 1816...	60	...	...
Commanders retired under O. C. of 1830...	50	...	...
Lieutenants	50	80	65
Masters of the fleet	60	90	80
Masters.....	50	80	65
Mates	...	60	50
Second Masters	...	60	50
Gunners warranted prior to 1830	25	...	...
Gunners not warranted prior to 1830	...		
Boatswains warranted prior to 1830	25		
Boatswains not warranted prior to 1830..	...		
Carpenters warranted prior to 1830	25		
Carpenters not warranted prior to 1830..	...	35	30
Masters of naval vessels warranted prior to 1830.....	25		
Masters of naval vessels not warranted prior to 1830.....	...		
ROYAL MARINES.			
General officers.....	120	According to circumstances.	According to circumstances.
Colonels.....	90	200	150
Lieutenant-colonels....	80	200	140
Majors	70	120	100
Captains	50	80	65
1st Lieutenants	40	60	50
2d Lieutenants	36	50	40
CIVIL BRANCH.			
Medical inspectors of hospitals and fleets....	80	200	140
Secretaries to commanders-in-chief.....	70	120	100
Deputy inspectors of hospitals and fleets...			
Paymasters-in-chief....	60	90	80
Inspectors of machinery afloat.....			
Chaplains	50	80	65
Secretaries to junior flag-officers.....			
Surgeons.....			
Paymasters.....			
Naval instructors			
Chief engineers			
Assistant-surgeons	40	65	50
Assistant-engineers	...	35	30

* If the officer was killed in action, or died within six months of wounds received in action.

† If the officer was drowned, or suffered other violent death in an immediate act of duty, or if it shall be proved to the satisfaction of the lords commissioners of the Admiralty that he has died from the effects of any injury or disease caused by extraordinary exposure or exertion on service within six months after his being first certified to be ill.

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PENSIONS TO THE MOTHERS AND SISTERS OF OFFICERS KILLED IN ACTION.

Mothers.—Where an officer is killed in action, and leaves no widow nor legitimate child, but leaves a mother who is a widow in distressed circumstances, and who was dependent upon him, the mother shall receive a pension equal to the ordinary rate of widow's pension attached to the rank which her son held at the time of his death; but if such mother shall herself be in receipt of a pension as an officer's widow, or shall have any other provision of any kind from the public, in that case no allowance will be made to her on account of her son, unless she gives up the other pension or allowance; and the pension given to a mother on account of her son will be forfeited on re-marriage.

Sisters.—The allowance made to the sisters of officers is not to exceed that which would be given to a mother, and will not be given in any case unless the officer shall have fallen in action, or shall die of wounds received in action, within six months after being wounded, and shall have left no widow, legitimate child, nor mother, nor unless the sister shall be an orphan, having no surviving brother, and shall have been dependent for support upon the officer killed. Every pension so granted will cease when the person receiving it shall marry, or be otherwise sufficiently provided for.

The widows of boatswains, gunners, and carpenters of the royal navy, and masters of naval vessels, appointed prior to the 30th of June 1830, will, if otherwise qualified, be entitled to a pension of L.25. Widows of the above warrant-officers, and the widows of engineers who shall have been warranted *subsequently* to the 30th June 1830, are not entitled to pensions unless their husbands shall have suffered a violent death, and provided they shall be otherwise entitled to the same, in which case the following pensions will be allowed:—

Art. 1.—To the widow of a gunner, boatswain, carpenter, or engineer, whose husband shall have been killed in action, a pension of L.35 a year.

Art. 2.—To the widow of any of the above-named warrant-officers, whose husband shall have been drowned on duty, or suffered a violent death in an immediate act of duty, a pension of L.30 a year.

Art. 3.—The pensions of all widows shall commence from the first day of the month following that in which their husbands died, provided application be made by the widow within twelve months from the same, otherwise from the time only of such application; and all applications for pensions must be addressed to the Secretary of the Admiralty.

Art. 4.—The widows of officers (except chaplains) who shall have married after the 31st of December 1830, are only entitled to the pensions of their respective classes in the event of their husbands having been on the list of commission or warrant officers, or on the list of naval instructors, ten complete years, except the husband be killed in action, or lose his life in the execution of the service.

Art. 5.—No widow shall receive a pension as a chaplain's widow, unless her husband shall have been in priest's orders, nor unless his name was on the list at the time of his death, nor unless she shall have been married during, or prior to, her husband's service in the navy, and unless her husband shall have served three years on full pay subsequent to their marriage, and shall have served the length of time to entitle him to his half-pay.

Art. 6.—No widow shall be entitled to the pension who has not been married twelve months to the officer by whose right she claims the same, unless the said officer was *killed* or *drowned* in the sea service; but the lords commissioners of the Admiralty may grant the pension, in such cases as they think proper, when officers die before the expiration of twelve months from the time of their marriage.

Art. 7.—If any officer shall marry after the age of sixty years, his widow shall not be entitled to receive the pension; or, if being capable of service, he should, at his own solicitation, be excused from it, being at the time warned that his widow would thereby forfeit the pension.

Art. 8.—The above pensions shall not be received by any widow together with any other pension from the government.

Art. 9.—Widows who shall have re-married after the 31st December 1830 shall forfeit their pensions.

Art. 10.—The pensions of widows who shall have re-married prior to the 31st of December 1830 shall be paid to themselves, and their receipts shall, notwithstanding their coverture, be deemed a sufficient discharge for the payment of their pension.

Compassionate Fund.

Besides these pensions, there has been established a Compassionate Fund, for the relief of such widows and orphan children as may appear to be proper objects of compassion. The sums annually required are voted by Parliament, and at present are limited to L.16,000 a year. One of the greatest benefits that could be conferred upon the Royal Navy would be to double the vote for the Compassionate Fund, which is quite inadequate for the object intended, and admits of very little compassion being shown to the orphan children of officers who have faithfully served their country.

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Pensions to petty officers and seamen are granted by the Board of Admiralty for wounds, infirmities, and length of service; and the sum required for this purpose is voted annually on the navy estimates.

In addition, however, to the pensions granted for wounds, and the pensions and compassionate allowances secured to the widows and children of officers, there are happily other provisions made for them by charitable institutions,—for instance,

Naval Knights of Windsor.

Naval Knights of Windsor, formerly called *Poor Knights*.—There is an asylum afforded at Windsor, by the will of the late Samuel Travers, Esq., for seven "superannuated or disabled lieutenants of English men-of-war, who are to be single men, without children, inclined to lead a virtuous, studious, and devout life; and to be removed if they give occasion for scandal." One of these, the senior officer, is appointed governor of the institution.

Queen Adelaide's College.

Queen Adelaide's College at Penge was established by her late Majesty for the widows of twelve officers of the ranks of lieutenant, master, surgeon, and paymaster. Each widow is allowed L.30 per annum, with coals and candles. The nominations are in the gift of the First Lord of the Admiralty.

The Royal Naval Benevolent Society.

The Royal Naval Benevolent Society, established in 1739. It affords relief to officers (being subscribers) of and above ward-room rank, and to their widows and families under misfortune and distress. The scale of subscription entitling to relief is so small that all officers would do well to support it. The following is the scale, viz.:—Flag-officers—annual, 1, 2, and 3 guineas; life, L.20. Captains, commanders, inspectors of hospitals and fleets, and secretaries—annual, 10s. 6d.; life, L.10. Chief engineers—annual, 6s.; life, L.6. Ward-room officers (including assistant-surgeons who are entitled to ward-room rank, and naval instructors)—annual, 5s.; life, L.5. It appears by the report that many cases have occurred where the widows, orphans, or other relatives entitled, have received hundreds of pounds for the husband's subscription of as many shillings. Thus, the sister of a deceased captain, for four years' subscription of L.1, 1s., received for his L.4, 4s. the sum of L.530. The orphans of a master, for six years' subscription of 5s., received for his L.1, 10s. the sum of L.182, 8s. A lieutenant, with eight children, for twenty years' subscription of 5s., received prior to his death L.170; and subsequently his widow the sum of L.88; and many other similar cases might be mentioned.

Queen Adelaide's Naval Fund.

Queen Adelaide's Naval Fund.—This fund was established in 1850 for the relief of the orphan daughters of officers of the Royal Navy and Marines. The dividends arising from donations and subscriptions are entirely appropriated to the relief of orphans, who are assisted by pecuniary grants bestowed at the discretion of the committee, and available either for the education of the young, the maintenance of the aged, or the casual assistance of those in temporary difficulty.

The Royal Naval School.

The Royal Naval School at New Cross, Kent, incorporated by Act of Parliament 1840, has been established a quarter of a century. The annual charge for board and education of the sons of naval and marine officers of ward-room rank is L.30, some are admitted at L.25, a limited number gratuitously, and at L.15 a year, according to the necessitous circumstances of the parents, a preference being given to orphans of those who may have fallen in the service of the country. A limited number of pupils, not being sons of naval or marine officers, are admitted on payment of L.50 per annum. Several young officers who

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were educated at this school distinguished themselves in the late war with Russia, and particularly so in the recent Arctic expeditions in search of Sir John Franklin and the crews of H.M. ships Erebus and Terror.

Royal Naval Female School.

The Royal Naval Female School, formerly at Richmond, and now St Margaret's, Isleworth, was established in 1840, for the purpose of bestowing upon the daughters of *necessitous* naval and marine officers, of and above the rank of ward-room officers, a good, virtuous, and religious education at the lowest possible cost. It owes its origin to the late Admiral Sir Thomas Williams, G.C.B., who invested L.1000 in trust; and by an additional contribution of L.100 per annum for seven years, arranged payments of the rents for that period. The Patriotic Fund made last year (1857) a grant of L.5000 to the institution. There are now 87 daughters of officers in the school; of these 26 are received at the annual payment of L.40; 56 (all daughters of necessitous officers) are boarded and educated at the entire cost to the parents or guardians of L.12 per annum; and 5 are nominees of the Patriotic Fund, whose fathers died during the late war with Russia, the establishment defraying the *larger* amount of actual cost through the means of voluntary contributions. Of the number of pupils on the reduced scale of payment, 5 have lost both parents, and 35 others have lost their fathers.

Orphan schools for seamen's children.

Neither are there wanting charitable institutions for the orphan children of seamen and marines at the several ports; and the recent establishment of sailors' homes for men-of-war's men and merchant seamen, at most of the ports throughout the United Kingdom, is one of the greatest boons that could have been conferred. It is impossible to speak too highly of those zealous and humane officers through whose exertions they have been established, more especially the late Captain Robert Elliot, who devoted the whole of his time and private resources on the first sailors' home that was opened in Wells Street, London; and the present Captain William H. Hall, C.B., who has been most indefatigable at every port in the kingdom. The late Sir Edward Parry was another zealous supporter of the sailors' homes, and of all institutions which had for their object the eternal as well as the temporal welfare of the British seaman. To his illustrious name must be added those of Admiral Bowles, the late Sir Francis Beaufort, the Hon. F. Maude, of Captain Gambier, and of many other well-known officers, who have also zealously devoted themselves to the object.

Sailors' homes.

These various institutions are now countenanced, and in some cases aided, by the government, by whom annual grants are made both to the orphan schools and sailors' homes. It would be well if these grants were made upon a more liberal scale.

Greenwich Hospital.

The establishment of *Greenwich Hospital* embraces much more extensive objects than any of the foregoing. The first idea of this noble institution,—the glory and ornament of the kingdom, which it is to be hoped that the restless spirit of innovation will leave untouched,—has been ascribed, with every appearance of justice, to Mary, the consort of William III. Being desirous that our gallant seamen, worn down by age or infirmities, as well as suffering from wounds, should not be left destitute, she made a grant, jointly with King William, of the palace of Greenwich, and of certain lands adjoining, to be appropriated to this purpose, in order, as stated in the king's commission, to "the making some competent provision, that seamen who, by age, wounds, or other accidents, shall become disabled for further service at sea, and shall not be in a condition to maintain themselves comfortably, may not fall under hardships and miseries, but may be supported at the public charge, and that the children of such disabled seamen, and also the widows and children of such seamen as shall happen to be slain in sea service, may, in some reasonable manner, be provided for and educated." In 1695 the committee appointed to examine and report on the premises recommended an additional wing to King Charles's building, which being approved by the king, Sir Christopher Wren undertook to superintend the new erections without any pay or reward. Since that time various additions and improvements have been made to this magnificent pile of building, which was completed, very nearly as it now appears, in the year 1778.

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The king granted L.2000 a year towards the carrying on, perfecting, and endowing of this hospital. The great officers of state and wealthy individuals also subscribed liberally to the undertaking. It was at the same time enacted by Parliament, that a deduction of sixpence per man per month should be made out of the wages of all mariners for the use of the hospital; and power was given to the Lord High Admiral to appoint commissioners for receiving the said duty, whose office is situated on Tower Hill. These deductions no longer exist, and the establishment has been broken up. In 1699 his Majesty contributed the sum of L.19,500, being fines laid by the House of Lords on certain merchants convicted of smuggling. In 1705 Queen Anne assigned to the use of the hospital the effects of Kid the pirate, amounting to upwards of L.6000. In 1707 Robert Osbaldiston, Esq., devised by will half of his estate, which was valued at L.20,000. In the same year Anthony Bowyer gave the reversion of a considerable estate for the use of the hospital. By several statutes the forfeited and unclaimed shares of prize-money were given to the hospital, and various grants from time to time continued to be made by Parliament. But the most substantial grant was that made by the Commons of the rents and profits of the forfeited estates of the Earl of Derwentwater, amounting at that time to about L.6000 a year, and at present to the gross rental of L.60,000, of which, after payment of all expenses for improvements, repairs, collections, and incumbrances, the annual receipt may be estimated at from L.30,000 to L.40,000.

Permanent revenues.

At present the permanent revenues of the hospital consist of the following heads:—

1. The duties arising from the North and South Foreland lighthouses.
2. The rents and profits of the Derwentwater estates, including the lead mines.
3. Rents of the market of Greenwich, and of certain houses there and in London.
4. Interest of money invested in the public funds.
5. Forfeited and unclaimed shares of prize-money
6. Fines for various offences.

It is evident that the funds of the establishment must vary considerably in times of war and peace; being lowest in the latter period, when the demands are heaviest upon it, especially for a certain number of years after the close of a war.

The rental of the estates belonging to the hospital in the counties of Northumberland, Cumberland, and Durham, rose from L.23,000, in 1805, to L.43,000, in 1816. The present gross rental of these estates and the lead mines, as above stated, amounts to about L.60,000; the North and South Foreland lights to L.7000; and the interest of funded property to L.50,000; making, with other contingencies, an annual revenue of about L.150,000, the whole of which is expended on the household establishment, the clothing, maintenance, and allowances to pensioners and other attendants, with repairs, taxes, and contingencies.

Hospital establishment.

The establishment of this noble institution consists of a military and civil department. In the former there is a governor, who is a flag-officer in the navy, lieutenant-governor, who is also a flag-officer, four captains, four commanders, eight lieutenants, and two masters; two chaplains, two physicians, five surgeons, and two dispensers, —all resident within the hospital. In the latter there are

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five civil commissioners, two of whom are *now* naval officers; a secretary and his assistant, a cashier, steward, clerk of the check,—each of whom has his chief clerk; an architect, and two inspectors of works, with their clerk. The number of in-pensioners is about 3000, and the number of nurses 180, all of whom must be the widows of seamen of the navy, and under the age of forty-five years at the time of admission.

Pensioned officers on Greenwich Hospital.

Under the naval administration of Earl Grey the following officers were added to the out-pensions of Greenwich Hospital, to be selected by the Admiralty according to their respective claims on the service:—

	Per Year.
10 Captains at	L.80
15 Commanders at	60
50 Lieutenants at	50

In addition to their half-pay.

Out-pensioned seamen.

The out-pensions to seamen were first established in the year 1763, by act of 3d Geo. III., c. 16, in consequence of which 1400 out-pensioners were appointed at L.7 per annum each, after undergoing an examination at the Admiralty as to their claims.

At the close of the long revolutionary war the applications became so numerous, and the claims of the seamen who had been wounded or worn out in the service so strongly grounded in humanity and justice, that it became necessary to adopt a scale of pensions, and to establish certain rules and regulations, by which seamen of Her Majesty's fleet and Royal Marines should be remunerated for wounds or hurts, debility, and length of service. The following are the present regulations:—

For Wounds, Hurts, or Debility.

Every seaman, landman, boy, or royal marine, wounded or hurt in Her Majesty's service, is entitled to a pension proportioned to his wounds or hurts, of not less than sixpence a day, and not more than one shilling and sixpence or two shillings a day. For sickness or debility, after seven years' service, and under special circumstances before that period, of not less than fivepence a day, nor more than tenpence, according as he may appear capable of assisting himself. Beyond fourteen, and less than twenty-one years' service, not less than eightpence, nor more than one shilling and threepence. And after twenty-one years' service, one shilling and sixpence a day. But the rates are altered from time to time.

All the above-mentioned pensions may be forfeited by misconduct, by desertion, and by sentence of a court-martial; also by neglecting or omitting to attend at such port or place, and at such time, as shall, in time of war or in prospect of a war, be appointed for the assembling of the pensioners, by the lords commissioners of the Admiralty.

In 1853 a committee of naval officers was appointed to consider the whole subject of manning the navy and granting pensions to seamen. Upon their recommendation, all boys entering the navy are now required to engage for ten years' "continuous service," from the age of eighteen, and are allowed to count time for pension from that age, instead of from the age of twenty, as heretofore. All men volunteering for ten years' continuous service are also allowed pensions after twenty years' service, instead of twenty-one. In order to insure a certain number of trained seamen, in the event of an armament, in addition to those borne on the peace establishment, seamen who have served ten years continuously in the navy, reckoning from the age of eighteen, are eligible, at the discretion of the Board of Admiralty, to be granted pensions of 6d. a day each, and men with fifteen years' service, pensions of eightpence a day each,—both classes being liable to give further service, if called upon, in the event of an armament. All men and boys, upon entering the service for the first time, and who may be granted pensions for twenty or twenty-one years' service, are held liable, under the pension stipulation, to give further service, if required, to meet the exigencies of an armament or of war.

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Naval Asylum.

To the noble institution of Greenwich Hospital is appended an asylum for the maintenance and education of the children of officers and seamen of the royal naval service.

The Naval Asylum was originally instituted by the Patriotic Fund and private subscriptions, and afterwards established at Greenwich, by warrant under the king's sign-manual, dated in January 1818, appointing the lords commissioners of the Admiralty to be commissioners and governors, who, with twenty-four directors, were to superintend and manage the same. The object was, the maintenance and education of a certain number of orphans and other children of the non-commissioned officers, seamen, and marines of the Royal Navy. As it was manifest, however, that this establishment, so contiguous to the hospital of Greenwich, could be managed without inconvenience by the commissioners and directors of that hospital, under a more effective and economical system, His Majesty was pleased, by his warrant of January 1821, to annul the former warrant, and to vest the superintendence and internal management of the said asylum in the commissioners and governors of Greenwich Hospital.

Greenwich schools.

The two schools of Greenwich Hospital and the Naval Asylum, and the funds thereof, are now therefore incorporated. The internal management is confided to the board of directors, and one of the captains of the hospital is intrusted with the general superintendence. The schools consist of the Nautical School and of the Upper and Lower School. A chaplain, and proper schoolmasters, matron, and inferior assistants, with moderate salaries, reside in the building. The number of children maintained and educated in the institution are,—

In the Boys' Upper School	400
... Lower School	400
In the whole	800

The Upper School is divided into two classes. 100 are the sons of commissioned and ward-room warrant-officers of the Royal Navy and Marines; and 300 are the sons of officers of the above or inferior rank, and of private seamen or marines of the navy, and of officers and seamen of the merchant service. The whole 400 are subject to the same regulations as to education, diet, clothing, discipline, and destination. None are admitted unless they can read fluently, write small text, and perform the first three rules of arithmetic. They must be free from infirmity of every description. The age of admission is from ten to eleven; and at fifteen, or sooner if qualified, the whole are sent to sea, either in the navy or merchant service, or are otherwise disposed of. Presentations by the directors in rotation.

The boys of the Lower School are the children of warrant and petty officers and seamen of the naval service, and non-commissioned officers and privates of the Royal Marines, admitted by the board of directors, giving a preference to orphans. The age of admission is from nine to eleven years inclusive; but none are retained beyond the age of fifteen. The boys are sent into the navy or merchant service, if situations can be provided for them; if not, they are to be taken away by their parents or guardians at the age of fifteen.

Thus all the classes of officers, seamen, and marines, who have faithfully served in the navy, are provided for by the state; and the children of such as may be in indigent circumstances receive an education at the public expense, suited to their condition in life.

The total expense of the navy, including every branch of the service, civil and military, for one whole year, about

Navy Bay || Naxos.

the middle of the war with France, was estimated at about L.18,000,000. In the year 1822, according to the estimates which were laid before Parliament, it amounted to about L.5,000,000; and in the year 1837, L.4,663,000; but it would be perhaps better to give a comparison between the year 1835–6 and the year 1856–7, an interval of 21 years. When at peace at the former period, the estimates amounted to L.4,245,723, with a vote for 20,000 men, 2000 boys, and 9000 marines. When at war with Russia during the latter period, the navy estimates amounted to L.16,298,155, with a vote for 71,000 men, being more than three times the number of seamen voted for 1835–6, and very nearly four times the amount.

Some idea may be formed of the prodigious increase of correspondence consequently conducted at Whitehall, by comparing the letters received and registered in the record department of the Admiralty at the same periods. In 1835–6, when Mr (now Sir Charles) Wood was secretary, and Mr Bedford held the office of keeper of the records, 25,973 letters were registered. In 1855–6, when Mr Osborne was secretary, and Mr Barrow (with *one* additional clerk) was in charge of the department, 49,181 letters were registered: the letters in the previous year having amounted to no less than 53,194, occasioning considerably more than double the amount of work in 1855–6, as compared to the period when Mr Wood was secretary.

The following table will show the increase in the navy estimates since the introduction of steam:— Naxos.

Year.	Men voted.		Sum voted.
1810.	Not given	L.1,508,451 15 11	
	Supplement	2,624 0 0	
			L.1,511,075 15 11
1820.	Not given	L.2,229,904 0 0	
	For conveying and victualling settlers to the Cape of Good Hope	86,760 5 4	
			2,316,664 5 4
1830.	29,000 men		5,595,855 5 8
1840–1.	35,165		5,847,516 0 0
1850–1.	33,446		6,672,588 0 0
1851–2.	33,610		6,543,255 0 0
1852–3.	33,619		5,835,588 0 0
1853–4.	39,407		6,285,493 0 0
1854–5.	50,907 (5000 seamen for 6 months.)		10,417,309 0 0
1855–6.	65,000		11,857,506 0 0
1856–7.	71,000		16,298,155 0 0
1857–8.	39,000		8,109,168 0 0

At the close of the war with Russia, the navy estimates (1857–8) were cut down from over 16 millions (as above) to L.8,109,168. They now stand (1858–9) at L.9,140,127: and it is to be hoped that they may not be reduced, if the Royal Navy is to remain in that state of efficiency, both in its *personnel* and *matériel*, which must be the ardent desire of every true lover of his country. (J. B—W.)

NAVY BAY, or LIMON BAY, an inlet of the Caribbean Sea, indenting the N. coast of the isthmus of Panama, in the republic of New Granada; N. Lat. 9. 21., W. Long. 80. It is about 5 miles wide at its mouth, stretches 4 miles into the land, gradually diminishing in depth, and can afford safe and convenient anchorage for many large vessels. On the western side there are several projecting headlands, which afford protection to vessels moored behind them, and which might be rendered still more secure by the construction of breakwaters. On the eastern side of the bay lies the island of Manzanilla, a mile and a half long by a mile in breadth; and between it and the mainland is a channel, with excellent anchorage and good shelter for small vessels under repair. This anchorage is capable of accommodating 300 ships, and has a depth of 6 or 7 fathoms in the centre. On the island of Manzanilla stands the town of Aspinwall, near which there is a railway across the isthmus to Panama.

NAXOS, or NAXIA, an island in the Grecian Archipelago, lying to the E. of Paros, the northern extremity being in N. Lat. 37. 12., E. Long. 25. 33. It is about 18 miles in length, by 12 in breadth, and has an area of 170 square miles. It bore the same name in ancient times; but was also called *Strongyle*, from its round shape; *Dionysias*, in consequence of the worship of Dionysus or Bacchus; and by the poets, *Dia*, in honour of Jupiter. In this island, according to ancient legends, Bacchus found Ariadne, who had been brought from Crete and left here by Theseus. It is said that the earliest inhabitants were Thracians; and that a colony of Carians afterwards settled here under a chieftain named Naxos, who gave his name to the island. It was afterwards colonized by Ionians from Attica; and from its size and fertility rose to great power and prosperity among the Cyclades. The original government of Naxos seems to have been oligarchical, but a tyranny was established by Lygdamis, who, after being expelled, was restored to power by Pisistratus of Athens, whom he had assisted to reinstate in the supreme power over Attica. This state of affairs, however, did not last long; and the aristocratical party again obtained for a time the upper hand; but having been expelled by the people, they applied for assistance to Aristagoras of Miletus, who induced the Persian king to undertake an expedition against the island. This expedition, sent against Naxos in 501 B.C., proved unsuccessful; but in 490 the island was reduced to subjection by the Persians under Datis and Artaphernes. At the battle of Salamis the Naxian contingent of four vessels deserted the Persians, and fought on the side of the Greeks. After the Persian war they joined the league of which Athens was at the head; but in 471 B.C., having revolted, they were reduced by the Athenians to a state of subjection. After this time few important events happened in connection with Naxos, till 1207 A.D., when a Venetian, named Marco Sanudo, took possession of this and some of the other islands, and founded a state, under the name of the Duchy of the Ægean Sea. This duchy, after a duration of 360 years, was destroyed by the Turks in 1566, under whom the island continued till the Greek insurrection, after which it formed part of the kingdom of Greece. The island is very fertile and picturesque; and produces vines, olives, oranges, pomegranates, figs, and other fruits. In the centre rises a mountain 3000 feet high, anciently called Drius, and now Zia or Dia; and there is also another eminence called Coronon, the name of which is probably derived from the nymph Coronis, the nurse of Bacchus. The rocks of Naxos consist principally of marble and granite, of which there are quarries; and the marble is hardly inferior to that of Paros. Iron ore is also found. The higher ground affords good pasturage for cattle. The resinous substance called *ladanum* is obtained here in modern as in ancient times. Near the north end of the island is a marble quarry, containing an ancient colossal statue, said to be one of Apollo, in an unfinished state. The principal town in the island is that of Naxos, which stands on the site of the ancient capital, on the west coast. It is irregularly built; and though it presents a fine appearance from the sea, the streets are narrow and dirty. It contains the remains of an ancient temple of Bacchus, and of the palace of the Venetian dukes, which was plundered by Barbarossa; and two moles, one ancient and the other modern, built by Marco Sanudo. The population of the town is about 4000. The island is the see of a Greek bishop and of a Roman Catholic archbishop, and has convents of both religions. There are numerous small towns and

Naylor ‖ Nazareth.

villages; and the entire population is estimated at 20,000.

NAYLOR, NAYLER, or NAILER, JAMES, an unfortunate fanatic, was the son of a farmer, and was born at Ardsley in Yorkshire about 1616. When the civil war broke out in 1641, he was living with his wife and family in the parish of Wakefield, and was probably engaged in agriculture. He took up arms for the Parliament, and during eight or nine years fought successively under Fairfax and Lambert. It seems to have been about this period that he first began to be seized with sudden religious impulses. He was converted from Presbyterianism to Independency. Then in 1651, two years after he had quitted the army and returned to the plough, the preaching of George Fox drew him into the community of the Quakers. An apostolic zeal immediately fired the new convert, and he abandoned his family and his occupation to become an itinerant preacher. His fevered imagination, untempered by a cool judgment, began to vent itself in the most fanatical opinions. The Quakers, as a body, disowned him; but a few silly men and women accepted his fluent ravings as inspired prophecies; recognised in his constant use of scriptural phraseology a sign of divine sanctity; and at length inferred from his habit of talking about "Christ being in him," that he was the very Son of God. It was no uncommon practice with these devoted disciples to leave their homes in different parts of the country, and to attend their prophet in his wanderings from city to city. Such enthusiastic worship quite overturned the previously tottering judgment of Naylor; so that he appears to have believed himself to be possessed of every supernatural attribute that was ascribed to him. His worshippers, encouraged by his acquiescence, soon brought their fanaticism to a crisis. They knelt before him and kissed his feet as he lay in Exeter jail in 1656, a sufferer for his extravagant zeal. On his release they celebrated his approach to Bristol by singing hosannas and by spreading their garments before his horse's path, in irreverent imitation of our Saviour's entrance into Jerusalem. At this point the government interfered, and apprehended Naylor, with six of his votaries, on the charge of blasphemy. His trial occupied the Parliament for several days. A few days afterwards their sentence was inflicted upon him. His head was fixed in the pillory for two hours, he was whipped at the cart-tail from the Palace-yard to the Old Exchange, his tongue was bored with a red-hot iron, and the stigma of a blasphemer was branded on his forehead. After a short respite, he was conveyed to Bristol, and whipped through the streets of that town. He was then brought back to bridewell, and doomed to an imprisonment of two years. These severe chastisements tamed the delirium and the spiritual pride of the fanatic. He recanted his heinous errors in several small books, and was re-admitted into the communion of the Quakers. In 1660, two years after his release, Naylor set out northward, to visit his long-forsaken family, but died by the way, in Huntingdonshire. A collection of his books, epistles, and papers was printed in 8vo, 1716. *Memoirs of the Life, Ministry, Trial, and Sufferings of James Naylor* appeared in 8vo, London, 1719.

NAZARETH, a town of Galilee in Palestine, stands on the western side of a narrow oblong valley, about 6 miles W.N.W. from Mount Tabor. Before the Christian era it seems to have been a paltry uninteresting village. It is not mentioned even once either in the Old Testament or in Josephus; and it is probable that it was the insignificance of the town itself, rather than the bad repute of its inhabitants, that prompted the exclamation of Nathanael, "Can there any good thing come out of Nazareth?" But the fact that our Saviour passed his youth and early manhood within its humble precincts, invested it with an interest which it has ever since retained, and which it will still retain as long as a single trace of its existence remains. It is now a well-built town, consisting of flat-roofed stone houses, and standing conspicuous amid a neighbourhood fertile with fig-trees, olive-trees, vineyards, and cornfields. The chief objects of interest in the town are the localities which are pointed out as the scenes of some of the events in our Lord's history, and the richly-decorated church of the monastery erected over a grotto which is supposed to contain the kitchen and fire-place of the Virgin. There is also shown the synagogue in which our Saviour expounded the Scriptures. About 2 miles from Nazareth stands the "Mount of Precipitation," which, as its name implies, is supposed to be the height from which he was about to be thrown by his fellow-townsmen. But how the credulous monks identify this precipice with the hill mentioned in Scripture as that "whereon the city was built," it is difficult to understand. The population of Nazareth is about 3000, of whom the majority are Christians of various denominations, and the rest are Mohammedans.

Nazarite

Neagh.

NAZARITE, or NAZARENE, a term which signifies one who is of Nazareth, or any native of the city of Nazareth. It was given to Jesus Christ and his disciples, and is commonly employed in a sense of derision and contempt by those authors who have written against Christianity. It has also been applied to a sect of heretics called Nazarenes, who sprung up during the second century in Palestine. Their main peculiarity consisted in the imagined necessity of combining the Jewish ceremonial with the religion of Jesus Christ. They refer to a Hebrew Gospel of St Matthew; and the Christian fathers make frequent allusion in their writings to the Gospel of the Nazarenes. This gospel was preserved by them in its primitive purity; but the Ebionites, a contemporary sect which they intimately resembled, and with which they have been often confounded, afterwards corrupted this scripture to suit their own heretical opinions. Both sects seem to have died out before the fifth century. Sometimes Nazarite means one who has laid himself under the obligation of a vow to observe the rules of Nazariteship, whether it be for his whole life, as Samson and John the Baptist, or only for a time, as in the case of those mentioned in Numbers vi. 18, 19, 20; and Amos ii. 11, 12. Lastly, the name Nazarite denotes, according to some, a man of particular distinction and great dignity in the court of some prince. *Nazir* is the Hebrew word employed to designate the dignity of the patriarch Joseph (Gen. xlix. 26; Deut. xxxiii. 16); and Calmet mentions that this word is still applied to the chief minister of the crown in Persia. (See Carpzov, *Appar.*, p. 151, sq., p. 798, sq.; Reland, *Antiq. Sacr.* ii. 10; Meinhard, *De Nasiræis*, Jen., 1676; Zorn, in *Miscell. Lips. Nov.* iv., 426, sq.; Spencer, *De Leg. Heb. Rit.* iii. 6; Dongtæi, *Analect.* i. 37; Lucian, *De Dea. Syr.*, c. 60; Mishna, *Nasir.*)

NEAGH, LOUGH, a lake of Ireland, province of Ulster, bounded N. and E. by Antrim county, W. by Tyrone, and S. by Armagh. It is the most extensive lake in the United Kingdom, and one of the largest in Europe, measuring 18 miles in length by 11 in breadth, and covering an area of 98,255 acres. The height of its surface above the level of the sea at low water is 48 feet, and its greatest depth is 102 feet. The lake is far from picturesque, and contrasts unfavourably with the other loughs of Ireland. Its shores are low and flat, and frequently become flooded after heavy rains. There are several islets, one of which, Ram's Island, is 6 acres in extent, and contains the remains of a round tower. The principal streams which flow into the lake are the Blackwater, the Upper Bann, and the Six-Mile Water; and its only outlet is the Lower Bann, which leaves the lough at its N.W. corner, and after flowing through Lough Beg, enters the sea near Coleraine. It is connected by canals with Belfast, Newry, and Lough Erne. It is navigated by small vessels; and one or two commodious ports or harbours are stationed along its coasts. The waters of the lough have

Neal ‖ Neander.

strong petrifying qualities, and the petrifaction is silicious and susceptible of a beautiful polish. The fish most abundant are the pollan (*Coregonus pollan*), a bright silvery fish, resembling the herring; and the *dollaghern*, a species of trout. Numbers of aquatic birds, such as the heron, widgeon, &c., frequent the shores.

NEAL, DANIEL, the author of an able *History of the Puritans*, was born in London in December 1678. After receiving his elementary education first at Merchant Tailors' School, and subsequently at a dissenting academy, he spent three years on the Continent, studying successively at Utrecht and Leyden. On his return in 1703 he commenced to preach. His learning and abilities recommended him in the following year to the office of assistant to Dr Singleton, the minister of an Independent congregation in Aldersgate Street. The Doctor died in 1706, and Neal was chosen his successor. He now appeared as a most faithful pastor, and at the same time as an assiduous cultivator of polite letters, especially of history. The *History of New England*, published in 1720, introduced him to the literary public. Meanwhile several of his sermons, preached for charitable purposes or on special occasions, were printed by request, and gained for him considerable fame as a pulpit orator. About 1729 he had risen so high in the estimation of his co-religionists, that he was requested to undertake an historical account of the Nonconformists. Accordingly, the first volume of *The History of the Puritans*, commencing at the Reformation in England, was published in 1732; the second followed in 1733, and the third in 1736. The fourth, bringing the narrative down to the Act of Toleration of 1689, was published in 1738. This history, though written in a calm and judicious spirit, was accused of being one-sided, and was attacked by Bishop Maddox and Dr Zachary Grey. Neal answered the former, and would in all probability have answered the latter also, had not his declining health prevented him. He died in April 1743. Neal's *History of the Puritans*, accompanied with a Life of the author, was edited by Toulmin in 6 vols., 1793. The same edition was reprinted in 3 vols. 8vo, London, 1837.

NEALCES, an ancient Greek painter, flourished in the time of Aratus of Sicyon, about the middle of the third century B.C. Little is known regarding either his life or his works. A Venus, and a painting of the naval battle on the Nile between the Egyptians and Persians, are mentioned by Pliny as two of his masterpieces. In the latter of these he very happily indicated the country in which the scene was laid, by representing a crocodile on the eve of seizing an ass that was drinking at the river. Nealces had a daughter named Anaxandra, who became an artist. The painter Erigonus was once his colour-grinder.

NEANDER, one of the most distinguished and influential of the modern theologians of Germany, was born at Göttingen in the beginning of 1789 of Jewish parents. His father Emmanuel Mendel, is said to have been a common Jewish pedlar; but little seems to be really known of his circumstances and character. His mother was a woman of tender and noble disposition; and from the maternal side, as in so many other cases, the virtues and talents of the son appear to have sprung. While still young, he removed with his mother to Hamburg; and in the grammar school, or Johanneum, of that city he received his classical education. There, as throughout life, the simplicity of his personal appearance, and the oddity of his manners, attracted notice, but still more, under all outward peculiarities, his great industry and mental power. His teacher, Gurlitt, took pride in his progress; and to the countenance and encouragement he thus received he owed much, which he always remembered with gratitude. From the Johanneum young Mendel passed to the gymnasium, where he attended for a year the prelections in philology, philosophy, and theology. The study of Plato appears especially to have engrossed him at this time. One of his young friends, Wilhelm Neumann, writes of him in 1806,—"Plato is his idol—his constant watchword. He sits day and night over him; and there are few who have so thoroughly, and in such purity, imbibed his wisdom. It is wonderful how entirely he has done this without any foreign impulse, merely through his own reflection and downright study." Neander.

Considerable interest attaches to his early companionship with the writer of this letter, and certain others, among whom were the afterwards well-known writer Varnhagen Von Ense and the poet Chamisso. This young band of students, strongly devoted to the romantic school of Tieck and Schlegel, had started a poetical periodical, in connection with which they formed themselves into a literary union, under the symbol of the Pole Star. The Star of the North, the region of enlightenment, was meant to signify their aspiring cultivation of the true and the beautiful. Varnhagen and Neumann having come to Hamburg, were attracted by the kindred spirit of the young Jewish student, and enrolled him in the brotherhood. He adopted the common symbol, and in virtue of his new connection opened up a correspondence with Chamisso, which was fortunately preserved by the latter, and gives us the deepest insight which we possess into his views and character at this period. The letters are singularly interesting. They breathe throughout the most simple and glowing enthusiasm; while the picture of a pure and affectionate nature, and the struggling comprehensiveness of a great spirit, are impressed on every page of them.

These letters enable us to understand with some degree of clearness the great change which now took place in Neander's convictions. They reveal a course of spiritual training very much analogous to that which he has described in many cases, with such remarkable power, in his *Church History*. He reached the gospel through Platonism. In that philosophy which, he continued to think, addresses itself more directly than any other to the divine instincts in man, and which, he has expressly said, "contains so much that really or seemingly harmonizes with Christian truth," he found those points of contact with Christianity which always attracted him more closely to it as a source of spiritual life, and the satisfaction of all his inward necessities. The ideals which in Plato "ravished his intellectual vision," and were at first worshipped with that intense devotion which leaves no room for any other worship in the heart of the student, he found in the gospel transmuted into realities, fitted not only to dazzle his intellect, but to pacify his heart and quicken and ennoble his whole being. Plato was thus his schoolmaster to bring him to Christ. And while he never ceased his admiration of the philosopher, he yet always came to embrace more and more, in its depth and purity, the "truth as it is in Jesus." The influence of his teacher's idealism may be visibly traced in some of his conceptions of Christian doctrine; but the divine simplicity and practical power of the gospel asserted themselves always more strongly in him. He was baptized on the 25th February 1806, and on this occasion adopted, instead of his Jewish name of David Mendel, that, under which he was always afterwards known, of Augustus Neander (νεος ἀνηρ).

In the same year he went to Halle to study divinity. He had matriculated at the gymnasium in Hamburg as *juris studiosus*; but with his new views, and the earnest spirit which animated him, he could now only serve the church. At Halle, Schleiermacher was then lecturing in the first height of his fame as a teacher. Neander met in him the very impulse which he needed, while Schleiermacher found a pupil of thoroughly congenial feeling, and one destined to carry out his views in a higher and more effective Christian form than he himself was capable of imparting to them. From this period we are to date Neander's devotion to

Neander. church history. Catching the enthusiasm and higher appreciation of his teacher, he began to live in studious communion with the fathers, and to amass those stores of divine wisdom and lore which he drew so copiously from their writings. His repose at Halle, however, was soon disturbed. The French having taken possession of the town after the battle of Jena, the university was suspended, and the professors and students scattered abroad. Neander had the misfortune, along with some other students, to be robbed by the French soldiers; and, friendless and ill from the fatigue of the journey on foot, he at length found refuge in his native city. Here he continued his studies with ardour, made himself yet more master of Plato and Plutarch, and especially advanced in sacred learning under the venerable Planck. The impulse communicated by Schleiermacher was confirmed by Planck, and he seems now to have realized that the original investigation of Christian history was to form the great work of his life.

Having finished his university course, he returned to Hamburg, and passed his examination for the Christian ministry with great distinction. He was not fitted, however, for the pulpit, and never seems to have commenced preaching. He betook himself to an academic career, and the study of Christian history, in Heidelberg, where two vacancies had occurred in the theological faculty of the university, from the removal of Mahreineke and De Wette to Berlin. He entered upon his work here as a theological teacher in 1811, commencing with a Latin dissertation on a subject which never ceased to attract him (*De fidei gnoseosque idea secundum Clementum Alex.*); and in the year following an extraordinary professorship rewarded his learning and industry. In the same year (1812) he first appeared as an author by the publication of his monograph on the Emperor Julian. The fresh insight into the history of the church, and the vivid and striking power of delineation evinced by this work,—vague and sketchy, perhaps, as it now seems in the light of his maturer productions,—at once drew attention to its author, and marked him as a rising theologian of the first rank. Accordingly, even before he had terminated the first year of his academical labours at Heidelberg, he was called to Berlin as the associate of De Wette and Schleiermacher—an illustrious band, whose labours have left an ineffaceable impress upon German theology.

In Berlin, Neander settled at once to those laborious habits of study and of earnest faithfulness in the discharge of his professorial duty which distinguished all his future career. His life was only varied by the successive publications which appeared in such fertility from his pen. In the year following his appointment he published a second monograph on St Bernard and his Age; then in 1818 his work on Gnosticism. A still more extended and elaborate monograph than either of the preceding followed on Chrysostom; and again, in 1825, another on Tertullian. He had in the meantime, however, begun his great work, to which these several efforts were only preparatory *studies*. The first part of his *General History of the Christian Religion and Church* made its appearance in 1825, embracing the history of the first three centuries. The remaining parts have appeared at successive intervals,—the last volume since his death, bringing down the narrative to the eve of the Reformation. Besides this great work, he published in 1832 his *History of the Planting and Training of the Christian Church by the Apostles;* and in 1837 his *Life of Jesus Christ, in its Historical Connection and Development*, called forth by the famous *Life* of Strauss. In addition to all these labours, he gave to the public many miscellaneous sketches from the history of the church and of theological opinion; as, for example, his *Memorabilia from the History of the Christian Life*, his volume under the title of the *Unity and Variety of the Christian Life*, and his papers on Plotinus, Thomas Aquinas, Theobald Thamer, Pascal, Newman, Blanco White, and Arnold, &c. Several brief works of a mixed exegetical and historical character have also come from his pen; and since his death a succession of volumes, representing his various courses of lectures, have been promised, of which two, containing his *Lectures on Dogmengeschichte*, admirable in spirit and execution, appeared last year (1857).

Neapolis ‖ Nearchus.

The life of Neander, as may be gathered from this mere enumeration, was one of unwearied work in his study and in his lecture-room. He lectured usually three times a day, his lectures embracing almost every branch of theology, exegetics, dogmatics, and ethics, as well as church history. He cherished the most warm and affectionate interest in his students, his ungrudging self-denial and benefactions in their behalf forming one of the most kindly traditions which surround his name. It is difficult to conceive a more child-like and yet more aspiring nature; at once so simple and so subtle—so lovely in affectionateness, and yet so grand and comprehensive in capacity and views. He died in 1850, worn out, and nearly blind, with incessant study. Germany mourned him as one of the greatest of her sons.

Our space will not permit us to enter into any full appreciation of Neander's theological and historical labours. This could only be done by showing at length his relation to the previous theology of Germany, and especially his connection with Schleiermacher, and the manner in which, while adopting, he modified and carried out the principles of this great thinker. With a mind less restlessly speculative, less versatile, discriminating, and logical, he possessed, in higher union than Schleiermacher, depth of spiritual insight and purity of moral perception with profound philosophical capacity. Characteristically meditative, while Schleiermacher was characteristically dialectical, he rested with a more secure footing on the great central truths of Christianity, and recognised more thoroughly their essential reasonableness and harmony. Strongly alive to the claims of criticism, he no less strongly asserted the rights of Christian feeling. "Without it," he emphatically says, "there can be no theology; it can only thrive in the calmness of a soul consecrated to God." And exactly in the same spirit, and proceeding from the same strong recognition of the absolute necessity of this Christian element in all theology, was his favourite motto,—"Pectus est quod theologum facit."

His *Church History* remains the greatest monument of his genius; and, upon the whole, the greatest work that has yet attempted to embrace so wide a field. Defective in graphic personal details and in a clear exhibition of the political relations of the church, somewhat heavy in style, with a certain vagueness and want of pictorial life throughout, it is yet unrivalled in its union of vast learning and profound philosophic penetration; its varied comprehensiveness and abundant store of materials; its insight into the living connection of historical events, but especially into the still more living and subtle nexus which binds together the growth and development of human opinion;—in its display of such qualities, with the most simple-hearted Christian piety, the most lively appreciative interest in the ever-varying fortunes of the church, the finest discernment of all the manifold phases of the Christian life, the most genuine liberality, and the most catholic sympathy. (J. T—H.)

NEAPOLIS. (See NAPLES.)

NEARCHUS, a distinguished ancient admiral, was the son of Adrotimus, and was born in Crete in the former half of the fourth century B.C. Obtaining a high position at the court of Macedon, he became a devoted friend of the young Alexander, and was banished on that account by the suspicious Philip. Alexander, on succeeding to the throne, recalled him; and Nearchus in 335 B.C. set out with the

Neath. king on his career of conquest. He was left behind in the following year to govern Lycia and Pamphylia. Five years afterwards, however, he joined the conquering prince once more in the far-distant province of Bactriana. But it was not until 325 B.C. that a high command was conferred upon him. A fleet was then launched upon the Hydaspes, and Nearchus was appointed to conduct it to the sea. This was effected in safety; but the more difficult task of leading the ships through the unexplored Indian waters to the Persian Gulf remained to be accomplished. Nearchus volunteered his services, which were gladly accepted. He set sail from the mouths of the Indus about the end of September 325 B.C. On approaching nearly opposite the western border of the Indians, the ships were obliged to tarry for twenty-four days in a port, afterwards called Alexander, until the north-east monsoon had set in. From this point the inexperienced mariners began to be encompassed with perils and objects of terror. A storm met them, and destroyed three of the galleys; they were under a perpetual dread of running upon rocks and shoals; huge sea-monsters rose upon the surface of the water, and threatened to overwhelm them; when they drew close to the land, ferocious savages, covered entirely with shaggy hair, and armed with nails like those of wild beasts, glared upon them from the shore. When at length, they arrived opposite the country of the Ichthyophagi, Leonnatus, who at the head of a land army had hitherto supplied them with provisions, could no longer attend them; and the barren sandy plain that extended for hundreds of miles along the shore could afford them no sustenance. The crews, appalled at the inevitable famine and the weary stretch of unknown sea that lay before them, became faint-hearted and refractory. At this crisis the indomitable energy of the admiral saved all from destruction. Overbearing the spirit of disobedience by his commanding firmness, he steered right onwards for many days, in spite of hunger, and danger, and discontent, until he landed his famished sailors on the fertile shores of Carmania. The remainder of the voyage was comparatively easy; and on the 9th December he brought his ships to anchor at the mouth of the River Anamis near the town of Harmozia. He then hastened to the camp of Alexander, which was pitched at a short distance in the interior, to announce his arrival. "By the Grecian Zeus and the Lybian Ammon!" exclaimed the king, "I swear to you I am more happy in receiving this intelligence than at being the conqueror of all Asia." From this date the facts known concerning Nearchus are comparatively unimportant. In the beginning of the following year (324 B.C.) he conducted his fleet to Susa. When the empire of Alexander was divided, his old provinces of Lycia and Pamphylia fell to his lot. He became an attached friend of King Antigonus. The latest mention of him in history is in 314 B.C., when he was appointed one of the counsellors of Demetrius, the son of the above-named monarch.

A narrative of the famous voyage of Nearchus is said to have been written by the navigator himself, and to have furnished the materials of Arrian's *Indica*. This opinion has been contested by Dodwell and other critics; but has been upheld by the generality of authorities, and especially by Dr Vincent in his *Commerce and Navigation of the Ancients in the Indian Seas*. The work just mentioned also gives a full account of the voyage.

NEATH, or NEDD (anc. *Nidum*), a parliamentary and municipal borough and market-town of South Wales, in the county of Glamorgan, on the left bank of the river of the same name, 7 miles E.N.E. of Swansea, 35 W.N.W. of Cardiff, and 208 W. by N. of London by railway. It extends along the edge of the river; and though neither well nor regularly built, it has some broad, well-paved streets. In the middle of the market-place stands a town-hall, built in 1837. The parish church is a large and ancient structure, with a square embattled tower; and there are several other churches. The town has a philosophical society, mechanics' institution, library, museum, and several almshouses. There are extensive copper and iron works, and the trade is considerable. The River Neath, which is here crossed by a bridge, is navigable for vessels of 300 or 400 tons up to the town, where there is a harbour with convenient docks. The principal articles exported are coal, iron, copper, tin, oak, and bricks; while copper and iron ore, corn, flour, timber, and other goods, are imported from foreign countries. Near the town are the remains of an old castle; and about a mile off, on the road to Swansea, are those of Neath Abbey; but very few traces now remain of the former splendour of either of these edifices. The borough is governed by a mayor, 4 aldermen, and 12 councillors; and unites with Swansea in returning a member to Parliament. The market-day is Wednesday; and three annual fairs are held. Pop. (1851) 5841. Nebraska.

NEBRASKA, a territory of the United States of North America, bounded N. by British America; W. by the Rocky Mountains, which separate it from Washington, Oregon, and Utah; S. by Kansas; and E. by Iowa and Minnesota. It lies between N. Lat. 40. and 49., and W. Long. 95. and 113.; and has an estimated area of 335,882 square miles. The country is still in its wild, primitive condition, and little is known of its topography, except in the neighbourhood of the Missouri and Platte rivers. The greater portion is an immense plain, sloping gradually from the Rocky Mountains in the W. to the Missouri in the E. Little of it is mountainous, except that part contiguous to the Rocky range. The principal rivers are the Missouri and its affluents the Platte, or Nebraska, and the Yellowstone. The country on both sides of the former tributary, as far up as the Elkhorn, is described as an undulating plain, here and there broken by ravines of considerable abruptness. But farther up the quality of the land deteriorates, and, except in the immediate vicinity of the river, is unfit for cultivation. The section of the territory at the head of Platte River, called the Black Hill district, is more elevated and is well watered. Many of the hills are covered with pine and cedar, and the valleys are said to be luxuriantly clothed with grass. From Fort Laramie, on the same river, there extends, for a distance of about 90 miles, a remarkable tract of land called "the Bad Lands," on account of its great sterility and forbidding aspect. It is studded with a number of columnar masses of sandstone from 100 to 200 feet high, which give it all the appearance of a vast, though quaint old town entirely deserted by its inhabitants. An interest of another kind has also been imparted to this place by a number of fossil skeletons of various tribes of animals now extinct, particularly of the *Pachydermata*, being found here, among which the skeleton of a *Palæotherium* was discovered 18 feet in length. The Platte valley forms one of the highways for overland emigrants to Utah and California. The river is from one to three miles broad, but yet so shallow, that, excepting at high flood, it is fordable at almost any part. The course of the stream is obstructed by numerous islands covered with cotton-wood, willows, and shrubs; while the shifting sand-banks and the rapidity of the current effectually prevent navigation. It rises among the Great River Mountains, and, under the name of the North Fork, flows E. by S., till joined by the South Fork, when it assumes the name of Platte or Nebraska River. It discharges its water into the Missouri near Platteville, after a course of about 1200 miles. The Yellowstone River, which waters the northern part of Nebraska, though not so long as the Platte, has a greater volume of water. It rises in Sublette's Lake, N. Lat. 43. 40., and W. Long. 110., and after a north-easterly course of about 1000 miles, joins the Missouri at Fort Union.

From the condition of the soil and surface of Nebraska,

Nebuchadnezzar.

it will in all likelihood become an agricultural country of some importance. The climate is warmer than in the same latitude east of the great lakes. Owing, however, to the vast extent of prairie land, the temperature is subject to sudden changes, and the country is exposed to the north and west winds, which sweep over the plains with great violence. It is reported that minerals exist to a considerable extent, and coal is said to have been lately discovered here. Emigrants have not as yet flowed into the territory in large numbers; and hence it is that here the Indians are found in greater numbers, and in a less civilized state, than in any other part of the Union. The government have assented to the construction of several roads through Nebraska, which, when completed, will no doubt tend greatly to the increase of its population. The territory formed a part of the Louisiana purchase, and came into the possession of the Union in 1803. It then comprehended the territory of Kansas, which was separated from it and organized a territory of the Union in 1854. Nebraska, as it now stands, received a like privilege in the same year. The capital town is Omaha city, situated on the west side of the Missouri. The entire white population was estimated in 1854 at 6000.

NEBUCHADNEZZAR, Nebuchadrezzar, or Nabopolassar, a great Chaldean king of Babylon. The account of his life given in the sacred narrative has received considerable elucidation from the canon of Ptolemy the mathematician, and from an extract preserved by Josephus out of a history by Berosus, a priest of the temple of Bel. From the combined import of these three narratives, we gather that Nebuchadnezzar, having virtually received the sovereign power from his infirm father Nabopolassar, set out at the head of a mighty army to chastise Necho, King of Egypt. The Egyptian monarch, after subduing the kingdom of Judæa, had advanced as far as the banks of the Euphrates, and had seized upon Carchemish (*Circesium*). There the youthful Chaldean prince met him, routed his army, and retook the captured city. The Jews, deprived of the support of their allies, yielded to the conqueror; their king Jehoiakim became a tributary of Babylon; and within two years the Egyptian influence in Syria was completely crushed. At this time (605 B.C.) Nebuchadnezzar received intelligence of his father's death. Leaving his army to conduct the captives and the spoils to Babylonia, he hastened home with a slender escort to assume the sole sovereignty. To consolidate his throne by an alliance, the young king married Amytis, the daughter of the King of Media. About the same time his great and splendid genius, unoccupied by schemes of conquest, began to find a congenial exercise in expensive improvements and gorgeous architecture. He decorated the temple of Belus to a superb magnificence with the treasures and the sacred vessels from Jerusalem; he planned stupendous canals, rivalling in depth and breadth the river Euphrates; and he laid the foundations of that massive and lofty palace, whose terrace-gardens, hanging from its sides like woods from the brow of a mountain cliff, became the wonder of the world. These peaceful occupations were interrupted by the intelligence that the Jews, instigated by Necho, King of Egypt, had rebelled. In the eighth year of his reign Nebuchadnezzar was besieging Jerusalem in person. The city was soon forced to surrender; the newly-appointed king Jehoiachim was deposed; the temple and the palace were plundered; no less than 50,000 captives, including Ezekiel the prophet, the nobles of Judah, and the craftsmen, followed in the train of the conqueror to Babylon; and Zedekiah, the brother of the late monarch, was left to govern the remnant. But no sooner had the Chaldean monarch departed to his distant capital, than his old enemies the Egyptians began to plot against him. They had induced Zedekiah to renounce his allegiance to Babylon, and had sent an army under their king Hophra to support him in his rebellion, when Nebuchadnezzar, at the head of all the forces of his empire, reappeared in Palestine. After driving the Egyptians back into their own country, he sat down before Jerusalem in 590 B.C. A hot siege of two years ended in the complete surrender of the city to his merciless vengeance. As a summary punishment upon the refractory Jews, he condemned their capital city to be first plundered of all its brass and gold, and then reduced to ashes, and their entire nation to be carried into captivity. The plunder of this expedition, like that of former expeditions, was devoted to the adorning of the royal seat of the conqueror with specimens of art and enterprise. One of these was the gigantic golden image which is mentioned by the prophet Daniel. Nebuchadnezzar was yet destined to be the minister of Divine vengeance upon the idolatrous Tyrians and Egyptians. At the end of an arduous siege of thirteen years, he took the city of Tyre, and levelled it with the dust. The Egyptians, who had added to their former provocations by sending succours to the besieged Tyrians, then became the object of his attack. Invading Egypt he marched from Migdol to Syene, overwhelming all resistance, taking numerous captives, and filling the entire length and breadth of the land with burning cities and slaughtered citizens. This campaign seems to have closed the military career of the Babylonian conqueror. He returned home to enjoy in peace the sway of that wide empire which had been won by his sword, and the splendour of that metropolis which had become under him the queen of the cities of the earth. His pride, pampered by the remembrance of an uninterrupted series of successes, swelled to a monstrous height. Walking one day in his palace, and looking down upon the imposing scene of magnificent houses around him, he burst out into an apostrophe of self-exultation. Immediately a voice fell from heaven, dooming him to live like a beast of the field until he should learn "that the Most High ruleth in the kingdom of men, and giveth it to whomsoever he will." In the same hour the arrogant, self-elated monarch was changed into a bewildered monomaniac that fancied himself an ox, and fled from the abodes of men to eat grass in the wilderness. At the close of seven years, he was restored to his reason and to his kingdom; and it is probable that the rest of his days were passed in that humility of spirit which becomes a creature. He died in 562 B.C. and was succeeded by his son Ilouaroudamos, or Evil-Merodach.

Neckar ‖ Necker.

NECKAR, a river of Germany, rises in Würtemberg, near the borders of Baden, in the Black Forest, not far from the source of the Danube. It flows in an irregular course, first N.E., traversing the N.W. corner of Hohenzollern, then N. through Würtemberg, and finally nearly W. through Baden, to the Rhine, which it joins at Mannheim. Its principal affluents are the Enz, on the left side, and the Kocher and Jagst, on the right. The towns of Rothenberg, Tübingen, Esslingen, Heilbronn, and Heidelberg stand on its banks; and those of Stuttgardt and Louisburg are in its vicinity. The whole length of the river is about 270 miles, and it is navigable as far up as Cannstadt, 120 miles from its union with the Rhine.

NECKER, Jacques, a statesman and financier of France, was born at Geneva on the 30th of September 1732. He was descended from a respectable family, originally from North Germany, and his father was a professor of law in Geneva. At the age of fifteen he quitted Geneva, and proceeding to Paris, entered first into the banking-house of Vernet, and afterwards into that of Thelluson, of which he became the cashier, and at length a partner. On the death of Thelluson, he established a bank on his own account, by which he accumulated a very large fortune. After twenty years of unremitting attention to his profession, he married a Protestant lady of respectable family, and having retired from business, was shortly afterwards named minister of the

Necker. republic of Geneva at Paris. In accepting of this employment, he refused the emoluments which were attached to it; a degree of forbearance not very usual in public men, but in which he resolutely persisted during the whole course of his political life. In 1769 he published the *Compagnie des Indes;* and the *Essai sur la Législation et le Commerce des Grains,* as well as the *Eloge de Colbert,* which was crowned by the French Academy, greatly extended the reputation of his political talents.

The disorder in the state of the French finances had become so alarming, that it was found necessary to break through the routine of official promotion, and to choose able men for the public service wherever they could be found. M. Necker, although a foreigner and a Protestant, was accordingly appointed in the year 1776 director of the royal treasury, and in the following year director-general of the finances. The great object of M. Necker was to introduce order and economy in the public management. With this view, he found himself compelled either to suppress useless offices, or to diminish emoluments; and his retrenchments drew upon him the enmity of all those who suffered by his economical reforms. He published in 1781 the well-known piece on the state of the finances entitled *Le Compte Rendu au Roi,* which had not the effect of lessening the number or violent hostility of his enemies. In order the better to struggle with his opponents, he made a demand for a seat in the Council, but was objected to on the ground of his religion. Being persuaded that this scruple would be abandoned, he persisted, and offered his resignation, which was accepted; and in this manner, as is alleged, he became the dupe of his own presumption.

He now retired to Switzerland, where he purchased the barony of Coppet. In 1784 he published an able work entitled *De l'Administration des Finances,* in 3 vols. 8vo, of which 80,000 copies were speedily sold. In 1787 M. Necker sent a memorial to the king, for the purpose of proving the correctness of his calculations in the *Compte Rendu.* His Majesty having read these documents, requested that they might not be published, a proposition in which Necker did not acquiesce, and for this offence he was exiled, by a *lettre de cachet,* 40 leagues from Paris.

Calonne, however, and the Archbishop of Toulouse were found unequal to the task of regulating the French finances, and were successively obliged to resign and make way for Necker, the favourite of the people, who was reinstated in his former post in August 1788.

At this period the French government was assailed by a complication of difficulties, the chief of which was the impracticability of raising the necessary supplies, and the danger of an immediate bankruptcy. A great scarcity also prevailed at Paris, which rendered the populace unusually discontented and tumultuous. Louis XVI. and his advisers pursued a weak and vacillating policy; and, when it was too late, desperately meditated even the most violent measures for the recovery of their authority. Troops were drawn from the most distant parts and encamped around Paris, intended to overawe the deliberations of the Assembly, or perhaps to dissolve it at once at the point of the bayonet. These violent courses M. Necker opposed, and he accordingly, at his own suggestion, was dismissed on the 11th July 1789, and requested to quit the kingdom in twenty-four hours. It is impossible to describe the consternation and wild confusion which prevailed in the capital when the dismissal and exile of this favourite minister was made known. His recall was demanded by the enraged populace, and a letter was written to Necker at Basle, requesting him to return. This popularity, however, was not of long duration. Being alarmed by the excesses which had already taken place, Necker became desirous to support the authority of the sovereign; and, without conciliating the confidence of the king's friends, he lost that of the popular party. His personal safety being now in danger from the violence of the people, he quitted Paris in the most private manner in the month of December 1790.

Nectar ‖ Needles.

After the loss of his power and popularity, Necker seems to have sunk into the greatest dejection. "I could have wished," says Gibbon, who passed some days with him about this period, "to have exhibited him as a warning to any aspiring youth possessed with the demon of ambition. With all the means of private happiness in his power, he is the most miserable of human beings; the past, the present, and the future, are equally odious to him. When I suggested some domestic amusements, he answered with a deep tone of despair, 'In the state in which I am, I can feel nothing but the blast which has overthrown me.'" He had recourse to writing to divert his melancholy; and several works which he published were the fruits of his labours during this period. He died at Coppet on the 9th of April 1804, after a short but painful illness.

His writings, besides those already mentioned, are,—*Memoire sur les Administrations Provinciales,* 1781; *De l'Importance des Opinions Religieuses,* 1788; *Sur l'Administration de Necker, par lui-même,* 1791; *Du Pouvoir Exécutif dans les Grands Etats,* 1792; *De la Revolution Française,* 1797. (See his *Memoires* by his illustrious daughter, Madame de Staël. A complete edition of Necker's *Œuvres* was published in 15 vols. 8vo, Paris, 1821.)

NECTAR, among the early Greek and Roman poets, was the drink of the gods (*ambrosia* being their food), and was fabled to have the power of imparting health, vigour, youth, and beauty to all who drank of it.

NEDJED, a district of Arabia. (See ARABIA.)

NEEDHAM, JOHN TUBERVILLE, was born at London on the 10th September 1713, and was descended from an ancient and noble family. He studied and taught rhetoric at the English college at Douay, conducted a Roman Catholic school near Winchester, and in 1744 was appointed professor of philosophy in the English college at Lisbon. Ill health soon compelled him to leave Portugal, and he passed several years at London and Paris, which were principally employed in microscopical observations, and in other branches of experimental philosophy. The results were published in the *Philosophical Transactions* of the Royal Society of London, of which he was a member, in 1749, and at Paris in 1750, in 1 vol. 12mo. An account of them was also given by his friend Buffon in the first volumes of his *Natural History.* From 1751 to 1767 he was chiefly employed as a travelling tutor, and in 1768 he retired to the English seminary at Paris. He afterwards received the appointment of chief director of the Imperial Academy, then instituted in the Austrian Netherlands, where he remained till his death, on 30th December 1781.

The papers of Needham inserted in the *Philosophical Transactions* are contained in vols. xlii., xliv., xlv., and li. He also wrote a curious pamphlet in connection with the controversy then in agitation respecting the origin of the Chinese, entitled *De Inscriptione quadam Ægyptiaca Taurini inventa, et characteribus, Egyptiis olim et Sinis communibus exarata,* 1761, in 8vo.

NEEDLES. These useful articles are made of steel wire, which may be *mill-drawn* or *hand-drawn.* The latter is preferred for the best needles, because, as in that case there is only one wire running at a time, the drawer can feel when the surface *rips* or *tears,* and can stop the process, so as to re-adjust the draw-plate and remove the damaged wire. In cleaning the wire after it has been softened, the scale is not removed by pickling in dilute sulphuric acid, but by the friction of rubbers smeared with emery and oil. The needle-maker obtains his wire in

Needles. coils of various sizes and weights, and his first operation is to cut it into lengths, each of which is sufficient for two needles. The curved pieces thus cut from the coils are straightened by inclosing many thousand lengths within a couple of rings, and rubbing them with an iron instrument called a *smooth file;* the friction of the pieces of wire upon each other producing the intended effect. Before this operation the wires are sometimes softened by being raised to a red heat, and allowed to cool gradually. The next process is to point both ends of the wires, which is done on small grit-stones; the grinder holding a number of wires in his left hand, and by a peculiar motion of the right hand making them roll upon the stone, so as to produce an accurate point. This dry grinding loads the air with particles of grit and of steel, which, entering the lungs, produce a fatal disease, known as *grinder's asthma.* The remedy for this is to attach to each wheel a ventilating apparatus capable of carrying off the dust as fast as it is formed. After the wires have been pointed, the centre of each is stamped or flattened out, and a groove is sunk on each side, together with a small cavity for the eye, by means of dies. One of the dies is contained in a block of iron resting on wood, and the other is attached to the bottom of a hammer, so connected with a lever as to be worked by the foot of the stamper; by which means the centre of each wire is flattened out, and the shape of the two eyes given. If it were attempted to form the eyes at one punching, the wire would probably be torn. In the next operation, called *eyeing,* a couple of steel points or cutters are brought down to punch out the eye. The wires are now threaded by their eyes upon a couple of wires, and the bur formed by stamping out the blank eyes is filed off. The lengths are next divided, by bending the wires backwards and forwards between the two wire spits; and shape is given to the heads of each row of needles by grasping the points in a hand-vice, and filing the heads upon a raised piece of metal. The needles are now said to be *headed* or *made,* and this completes the processes known as *soft work,* from the soft state of the wire. Before the finishing processes known as *bright work* are entered on, the needles are straightened by rolling them on a flat steel plate with the convex face of a curved smooth steel file. The next process is *hardening:* the needles being raised to a red heat are suddenly quenched in cold water or oil, after which they are tempered by a more gentle heating on an iron plate, the proper temper being judged of by the formation of a blue film upon the surface. In this operation the needles become more or less distorted, and they are straightened by being tapped upon an anvil with a small hammer: this is called *hard* or *hammer straightening.* The needles are examined by rolling with the finger on a smooth plate of steel, and such as do not roll truly are corrected with the hammer. The needles are now made up with canvas, in bundles of from 40,000 to 50,000, with emery, oil, and soft soap, each bundle being about 2 feet in length, and 3 or 4 inches in diameter. These rolls are placed in a scouring machine, resembling an ordinary mangle, and the bundles being made to roll backwards and forwards during many hours, such an amount of friction is produced on the needles as to make them bright and smooth. After about eight hours' friction the bundles are taken out and re-made, with the addition of putty-powder and oil. For the best needles the scouring or cleaning and polishing is continued for seven or eight days. The heads of the needles are now softened by placing them in rows upon metal strips, with the eyes projecting over the edge, and bringing a red-hot plate sufficiently near to produce the deposit of a dark blue film on the heads. This indicates the proper temper for the next operation, which is the very delicate one of removing sharp or jagged portions from the interior of the eye. This is done by *drilling,* the drills being minute three-sided tools attached to a wheel, and revolving rapidly. The operator brings each eye up to the drill, first on one side and then on the other; first *countersinking,* as it is called, or converting the sharp edge of the eye, where it communicates with the groove, into a curved one; after which the drill is made to pass round the rest of the eye in such a way as to produce the kind of curve seen in the bow of a pair of scissors. The points are next finished upon a small revolving stone, after which they are polished on wheels of wood coated with buff leather and polishing paste. The needles are lastly counted into quarters of hundreds, folded up in papers, and labelled. Recently they have been sold in cases, containing several small tubes, each tube holding a different size of needle.

Needles, The || Neemuch.

The needle-making district of England includes the villages of Redditch, Feckenham, Beoley, Studley, Coughton, Alcester, Astwood Bank, Crabb's Cross, &c.; all of which lie near together. It should be noticed that the manufacture differs somewhat for the heavier kinds of needles, such as packing, sail, upholsterers', stay, mattress, bookbinding, surgeons', harness, and collar needles; knitting, netting, tambour, and crochet needles; and meshes. (C.T.)

NEEDLES, THE, a name given to five remarkable rocks lying immediately off the western extremity of the Isle of Wight, in N. Lat. 50. 39., and W. Long. 1. 34. Their origin is attributable to the sea beating on the sharp cliffs which form the W. point of the island, and the same influence is gradually wasting them away; the largest of them, which was 120 feet in height, having been submerged in 1764. They are white, but black at their bases, and curiously streaked throughout with black strata of flints. A lighthouse standing on this extremity of the island rises 715 feet above the sea.

NEEFS, PETER, surnamed "the Elder," an eminent Flemish painter, was born at Antwerp in 1570. He studied under Steenwyck the Elder, and, like his master, directed his attention to the painting of the interior of churches and convents. His delicate finish, exquisite colouring, and correct execution of perspective, soon placed his pictures among the best of their class. The figures which he employed Jan Breughel, Teniers, or other eminent artists, to introduce into his churches, added much to the effect. Neefs died about 1650. His son, called Peter Neefs "the Younger," imitated him both in the selection of subjects and in style, but with no great success.

NEEMUCH, in Hindustan, a town with a British cantonment, in the territory of Gwalior, or possessions of Scindia, situated on the N.W. border of Malwa, at a short distance from the boundary which separates that tract of country from Mewar. Bishop Heber describes the cantonment as a stationary camp of thatched bungalows and other buildings, open on all sides, and surrounded by a fine plain for the performance of military evolutions. Wallich, a later traveller, gives the following account of it:— "The cantonment extends on a slightly elevated ridge, running about N.W. and S.E.; its extreme length is 2½ miles, and the extreme breadth 1 mile. The lines are placed in front, facing to the northward; the regimental officers' quarters behind these; and the Sudder Bazaar and staff to the rear of all. Lines have at various periods been built capable of containing one regiment of native cavalry, one troop of native horse artillery, four regiments of native infantry, and a regiment of irregular horse." A small fort has been constructed by the British as a place of refuge for the families of the military, when called to a distance on duty. The native troops stationed at this place participated in the general mutiny of the Bengal army. The rising took place on the night of the 3d June 1857, when a general massacre of Europeans took place. The work of slaughter was commenced by the artillery, and all the native troops joined heartily in it. A native officer opened

Neer ‖ Neff.

the gate of the fort, and gave entrance to the rebels. Having committed the most frightful enormities, and outraged every law of humanity, a large body of the miscreants marched in the direction of Agra. (Some account of their subsequent proceedings will be found under the article NORTH-WESTERN PROVINCES OF BENGAL.) Neemuch is distant 312 miles from Agra, and 371 from Delhi; N. Lat. 24. 27., E. Long. 74. 54.

NEER, ARNOULD, or AART VANDER, "the prince of moonlight painters," was born at Amsterdam in 1619. His paintings soon became remarkable for their fidelity to nature, and for their calm poetical tone. He excelled in representing winter scenes; but his favourite subject was the moon shedding down her silver light upon a sleeping hamlet, in the midst of a few trees on the bank of a smooth-flowing river. These moonlight pieces are found all over Europe, and are marked by a monogram, consisting of A. V. D. N. Neer died in 1683.

NEER, *Eglon Hendrick Vander*, an eminent artist, was the son of the preceding, and was born at Amsterdam in 1643. His first lessons in painting were received from his father. He then became the pupil of Jacob Vanloo, and about the age of twenty followed his teacher to Paris. His principal studies, however, seem to have been the masterpieces of Gaspar Netscher, William Mieris, and Terburg. It was soon apparent that he had caught some of the several excellencies of these famous artists. A more striking feature of his pictures, however, was an elaborateness in detail. On every kind of subject which he painted he employed the careful and minute attention of one who strives to build his reputation on a few highly-finished masterpieces. His pictures of conversational parties are crowded with the most splendid accessories; and owing to the excessive finish of his trees and flowers, his historical pieces ought to be called landscapes, and his landscapes ought to be called garden pieces. Neer died in 1703, at the court of the elector-palatine at Düsseldorf. Specimens of his paintings are to be seen in the Bridgewater collection, and in the collections of Mr Hope and the Marquis of Bute.

NEFF, FELIX, a devoted Swiss missionary, was born at Geneva on the 8th of October 1798. He received his early education chiefly from his widowed mother, who was distinguished for her piety; and occasionally had the benefit of a lesson from some kind pastor of his native canton. The favourite authors of his boyish years were Plutarch and Rousseau; and he took great interest in the study of natural history and mathematics. He was placed at an early age with a florist-gardener in the environs of Geneva, and at the age of seventeen entered the army, that he might no longer be a burden to his poor mother. Here his patient industry and excellent character soon raised him to the rank of serjeant; but his earnest, thoughtful nature becoming greatly impressed with the truths of religion, he was induced in 1819 to exchange the life of a soldier in the garrison of Geneva for that of a Protestant missionary in the wild glens of the High Alps. The first years of his missionary life were spent as a *proposant* or catechist in the cantons of Geneva, Neufchâtel, Berne, and the Pays de Vaud. In 1821 he turned his attention to the destitute district of Grenoble in France, and subsequently to that of Mens in Isère, with the hope of making "recruits," as he was wont to phrase it. He went to England in April 1823, and after obtaining clerical ordination from the Independents there, he returned to the scene of his former labours at Mens. A short time afterwards, we find him among the High Alps, pursuing his noble undertaking with great courage and zeal among the descendants of the Vaudois, in the wild picturesque valleys of Queyras and Freyssinières. Here he dedicated temples, organized schools, and laboured incessantly, "by day and night, through wind, snow, and ice," among those lonely glens and savage mountains, until he broke his health. The baths of Plombières were visited without any permanent effect, and he returned to native Geneva only to die. Small companies of the poor people of the distant Alpine valleys made long journeys on foot through the snow to see their dying pastor; but the spring of 1829 put an end to his sufferings, and sent these devoted ones back to their native wilds in tears. (*The Life of Felix Neff*, by A. Bost, London, 1855.)

Negapatam ‖ Negropont.

NEGAPATAM, a considerable seaport in the south of India, and province of Tanjore. It was formerly well fortified, and had a citadel of a pentagonal form, with wet ditches. It has no considerable trade, but is frequently touched at by ships for refreshments, which are plentiful. The town lies at the north side of the citadel, near which is the mouth of a small river, capable of receiving vessels which draw little water. At the mouth of the river there is a bar, over which the surf breaks with great violence in bad weather, and renders the entrance dangerous. The anchoring place is about 3 miles from the shore, opposite the town, where there is very little current; and to the S.E. of the town, at the distance of 5 miles, there is a shoal about 5 miles in length, having from 3 to 6 fathoms water on it. It was originally a small village, but was fortified and improved by the Portuguese. In 1660 it was taken from them by the Dutch, who strengthened its fortifications, and made it the capital of their settlements on the Coromandel coast, where they established a mint. Under their rule it enjoyed a long period of tranquillity; its trade increased, and it became a very flourishing city. In 1781 it was besieged and taken by the British with about 4000 troops, and was finally ceded to them at the peace of 1783; since which period the fortifications have been neglected, and the trade has been transferred to other places. E. Long. 79. 55., N. Lat. 10. 46.

NEGRAIS, an island, harbour, and cape of the Eastern Peninsula, is situated at the S.W. extremity of the kingdom of Pegu, in N. Lat. 16. 1., E. Long. 94. 12. The island is small, and is now deserted and overgrown with jungle; but the harbour is one of the safest in the Bay of Bengal. In 1687 a settlement was founded here by the British government of Madras, but it was soon after abandoned. In 1751 it was again for a short time occupied by the British; and in 1757 was ceded to them by the Burman emperor; but two years afterwards, the Burmese attacked it, and put to death all the inhabitants who did not succeed in effecting their escape.

NEGROES. See ETHNOLOGY, and AFRICA.

NEGROPONT, or CHALCIS, a town of Greece, capital of Eubœa, is situated on the Euripus, which separates that island from the mainland, and is here at its narrowest point only 40 yards in breadth. It is built in the form of a crescent, touching the sea at each extremity, and surrounding the citadel, or *castro*, as it is termed, which stands on a lofty rock overlooking the straits. The fortifications of the citadel are partly of Venetian and partly of Turkish construction; while the outer walls of the town, which are now in a state of great dilapidation, are Venetian. The streets are narrow, but there are many good houses, especially those built by the Venetians. There is also a Gothic church with square towers; and, as a few Mohammedans still remain in Negropont, one of the mosques is used by them in its former capacity, while the others have been converted into Christian churches. The gate of the citadel is surmounted by the lion of St Mark. In the middle of the straits is a small rocky islet, on which stands a tower; and this is connected with the mainland by a stone bridge about 70 feet long, and with the island by one of wood 35 feet long, with a drawbridge at each end, to allow the passage of ships. The ancient name of the town was *Chalcis;* and it was a place of great importance in antiquity. Strabo

Negro, Rio.

informs us that it was twice colonized by Ionians from Attica in early times. It soon became one of the greatest commercial towns of Greece, and sent out a large number of colonies to various parts of the world. The peninsula of Chalcidice in Macedonia obtained its name from the number of Chalcidian colonies founded there. Cumæ and Rhegium in Italy, and Naxos, Zancle, and Tauromenium in Sicily, are among the cities which owed their origin to Chalcis. The government was originally in the hands of an aristocracy, called *hippobotæ*, who were in all probability the proprietors of the rich plain of Lelantum, between Chalcis and Eretria. This plain was claimed by both of these cities; and at an early period a war took place between them, in which Miletus and Samos took part. After the expulsion of the Pisistratidæ from Athens, the Chalcidians joined the Bœotians in a war against that city; but the Athenians, in 506 B.C., invaded the island with a large force, and after a complete victory, divided the lands of the nobles among 4000 Athenian settlers. These, however, retired from the island on its invasion by the Persians in 490 B.C. After the Persian war, Eubœa joined the Athenian confederacy, and continued in that alliance till 445 B.C., when a general insurrection took place in the island against Athens. It was, however, soon re-conquered and reduced to subjection by Pericles, and the aristocracy of Chalcis were deprived of their power. In 411 B.C., after the disastrous end of the Athenian expedition to Sicily, the whole of Eubœa again threw off the Athenian yoke, and the bridge across the straits was then first built, in order to secure the communication with Bœotia. The island continued independent for some time, and joined the Theban confederacy against Sparta; but when the Athenian power was again in the ascendant, the cities of Eubœa became once more subject to her supremacy, and were governed by tyrants. About 350 B.C., Callias and Taurosthenes, joint tyrants of Chalcis, wishing to obtain the sovereignty of the whole island, asked the assistance of Philip of Macedon, who readily acceded to their request; but Plutarch, tyrant of Eretria, having applied to the Athenians for aid against this attempt, they sent an army under Phocion, by whom the Chalcidians were defeated. The Macedonian party, however, still retained their power in Chalcis; and soon the influence of Philip was predominant throughout the island. Owing to its strength and position, Chalcis was a place of much importance in the contest for the dominion of Greece which took place after the death of Alexander, and it was frequently taken in these wars. In later times it fell successively into the hands of Antiochus and Mithridates and was finally taken and destroyed by the Romans, by whom Eubœa was included in the province of Achaia. From this time the island continued undisturbed under the power of Rome, and under that of Constantinople after the division of the empire, until the Latin conquest of the East in 1204 A.D. At that time the island came into the hands of the Venetians, who retained possession of it till 1470, when the city of Negropont, as it was then called, was taken by the Turks, and the inhabitants cruelly massacred. In 1688 the Venetians made an unsuccessful attempt to retake the town. Since the Greek revolution, Eubœa has formed part of the modern kingdom of Greece; and as the ancient appellations have been by law restored, Eubœa and Chalcis are now the names by which the island and town are most commonly known. Pop. of the island (1852), 65,299; of the town, 5000.

NEGRO, Rio, a river of South America, forming the boundary between Patagonia and the Argentine Confederation, takes its rise in the Andes by two head-streams, one from the north and the other from the south, and flows eastward to the Atlantic, into which it falls in S. Lat. 41., W. Long. 62. 50., after a course of from 500 to 600 miles. It is full of small islands and sand-banks; and about the middle of its course it separates into two branches, which inclose an island of considerable size. The river is subject to two annual floods, one of which, in December and January, is occasioned by the melting of the snows of the Andes; and the other, in June and July, by the heavy rains in the interior. The river is about 2 miles broad at its mouth; but at the town of Carmen, about 16 miles from the sea, it does not exceed 300 yards in width. Near its entrance is a bar, over which there are several channels, some of which may be crossed by vessels drawing 11 feet of water. The climate of the district is healthy; and though very warm in summer, ice is frequently formed between the months of April and July. The winds are very variable, and frequently violent. The principal town on the river is Carmen, on the north bank, with a population exceeding 1000.

Negro, Rio ‖ Nehemiah.

NEGRO, *Rio*, one of the principal tributaries of the Amazon, rises in New Granada by two head streams, and flows eastwards till it falls into the Amazon, in S. Lat. 3. 16., W. Long. 59. Its principal affluents are the Cassiquiare, by which it is connected with the Orinoco, the Cababure, Padaviri, and Branco, from the N.; and the Tomo, Zie, Haupes, &c., from the S. and W. In the lower part of its course the river flows through a succession of lakes from 15 to 20 miles broad: at its junction with the Amazon it is about 1½ mile in breadth. The river is flooded during the months of August and September, when it rises about 30 feet above its lowest level. The length is about 1000 miles.

NEGROS, one of the Philippine Islands, lies between N. Lat. 9. 3. and 10. 58., and between E. Long. 122. 28. and 123. 29.; being separated by narrow channels from the islands of Panay on the N.W., and Zebu on the E. It is about 140 miles in length, with an average breadth of 25 miles, and an area estimated at 3827 square miles. A range of mountains traverses the island from N. to S., and it is watered by numerous rivers. The interior is little known; it contains large forests abounding in beautiful and valuable timber. Coffee, tobacco, and rice are cultivated; and palms and cocoa-nut trees also grow on the island. Wax, honey, palm oil, rock-crystal, pearls, sulphur, &c., are among the productions of Negros. The climate is generally healthy; but the island is subject to earthquakes. The inhabitants of the interior are rude and uncivilized; and there are few Spanish settlers. The governor resides at Timamailan, where there is a church and a small harbour. Pop. of the island, 35,622.

NEHEMIAH, a distinguished Jewish patriot, and author of the book of Scripture which bears his name, was the son of Hachaliah (Neh. i. 1), and brother of Hanani (vii. 2). His genealogy is unknown. Some think, however, that he was of priestly descent, because his name appears at the head of a list of priests in chap. x. 1–8; but it is obvious, from chap. ix. 38, that he stands there as a prince, and not as a priest. Others with some probability infer, from his station at the Persian court, and the high commission he received, that he was, like Zerubbabel, of the tribe of Judah and of the house of David (Carpzov, *Introductio*, &c., p. i. 339). While Nehemiah was cup-bearer to Artaxerxes Longimanus in the royal palace of Shushan, 444 B.C., he learned the mournful and desolate condition of the colony returned to Judæa. This filled him with such deep concern, that his sad countenance revealed to the king his sorrow of heart, which induced the monarch to send him with full powers to rebuild the wall of Jerusalem, and "to seek the welfare of the children of Israel." Nehemiah reached Jerusalem B.C. 444, and remained there till B.C. 432 (v. 14). The principal work then accomplished by him was the repairing of the city wall, which was done "in fifty and two days" (vi. 15), notwithstanding many discouragements and difficulties, caused chiefly by Sanballat, a

Nehemiah.

Moabite of Horonaim, and Tobiah, an Ammonite, who were leading men in the rival and unfriendly colony of Samaria (iv. 1–3), as well as by certain of the Jewish people themselves. Nehemiah, however, displayed great firmness, sagacity, and zeal; and the completion of the wall was most joyously celebrated by a solemn dedication under his own direction (xii. 27–43).

Having succeeded in fortifying the city, he turned his attention to other measures, in order to secure its good government and prosperity (vii. 1–3; xii. 44–47; viii. 1–12; viii. 13–18; ix.; x.; vii. 4; also xi. 1–19). In these important public proceedings, Nehemiah enjoyed the assistance of Ezra, who had gone up to Jerusalem a number of years previously. (See EZRA.)

At the close of his successful administration Nehemiah returned to Babylon in the year 432 B.C., and resumed, as some think, his duties as royal cup-bearer. He returned, however, to Jerusalem, probably about 424 B.C., where his services became again requisite, in consequence of abuses that had crept in during his absence. (See Prideaux, i. 520; Jahn, *Einleitung ins A. Test.* ii. 288; Winer, *Realwörterbuch;* also, Hävernick, *Einleitung ins A. Test.* ii. 324.) The duration of this second administration, during which he effected many important reforms, both social and religious, cannot be accurately determined, but it probably lasted ten years, namely, from 424 to 413 B.C. It is not unlikely that he remained at his post till about the year 405 B.C., towards the close of the reign of Darius Nothus, who is mentioned in chap. xii. 22. At this time Nehemiah would be between sixty and seventy years old, if we suppose him (as most do) to have been only between twenty and thirty when he first went to Jerusalem. That he lived to be an old man is thus quite probable from the sacred history. Josephus (*Antiq.* xi. 5, 6) states that he died at an advanced age; but of the place and year of his death nothing is known. Besides the account in Josephus, there are some honourable notices of Nehemiah in the Apocrypha.

NEHEMIAH, *The Book of*, was anciently connected with Ezra, as if it formed part of the same work (Eichhorn, *Einleitung*, ii. 627) (See EZRA.) From this circumstance some ancient writers were led to call this book the 2d book of Ezra, and even to regard that learned scribe as the author of it (Carpzov, *Introductio*, &c., p. 336). There can, however, be no reasonable doubt that it proceeded from Nehemiah, for its style and spirit, except in one portion, are wholly unlike Ezra's.

The canonical character of Nehemiah's work is established by very ancient testimony. It is not expressly named, however, by Melito of Sardis (A.D. 170) in his account of the sacred writings; but this creates no difficulty, since he mentions Ezra, of which, as we have seen, Nehemiah was then considered a part. The work is properly a collection of notices of some important transactions that happened during the first year of Nehemiah's government, with a few scraps from his later history. The contents appear to be arranged in chronological order, with the exception perhaps of ch. xii. 27–43, where the account of the dedication of the wall seems out of its proper place: we might expect it rather after ch. vii. 1-4, where the completion of the wall is mentioned. While the book as a whole is considered to have come from Nehemiah, it consists in part of compilation. He doubtless wrote the greater part himself, but some portions he evidently took from other works. It is allowed by all that he is, in the strictest sense, the author of the narrative from ch. i. to ch. vii. 5 (Hävernick, *Einleitung*, ii. 304). The account in ch. vii. 6–73 is avowedly compiled, for he says in ver. 5, 'I found a register,' &c. This register we actually find also in Ezra ii. 1–70: hence it might be thought that our author borrowed this part from Ezra; but it is more likely, from their obvious discrepancies, that they both copied from public documents, such as "the book of the chronicles" mentioned in Neh. xii. 23, which were not themselves harmonious. The exegetical helps for the explanation of this book are chiefly Poole's *Synopsis*, Lond. 1669–76; Jo. Clerici, *Comm. in Lib. Historicos V. T.*, Amst. 1708; Maurer, *Comment. Crit. Grammat. in V. T.*, vol. i., Lips. 1833; Strigelii, *Scholia in Nehem.*, Lips. 1575; and Rambach, *Annotationes in Librum Nehemiæ*, Halæ, 1751.

Nehrung ‖ Neisse.

NEHRUNG, CURISCHE, a long strip of land in Prussia, in the province of East Prussia, about 60 miles in length, and nowhere above 3 in breadth, separating the lagoon called the Curische Haff from the Baltic. It consists of sand, and is entirely barren. Several villages have been buried by the gradual accumulation of the sand.

NEHRUNG, *Frische*, a similar sandy strip in West Prussia, between the Frische Haff and the Baltic.

NEILGHERRIES, in Hindustan, a range of mountains in the presidency of Madras, situated between N. Lat. 11. 10. and 11. 35., E. Long. 76. 30. and 77. 10. This remarkable range is connected on its western side, where its summits bear the name of the Koondahs, with the Siadri branch of the Western Ghauts, here terminating in a southern face of lofty and perpendicular precipices, and forming the north side of the great Palghat valley or depression, which, extending east and west with a breadth of about 20 miles, affords an easy communication between the Carnatic and Malabar. The general outline of the Neilgherry group approaches to a triangle, having the side which may be regarded as the base extending nearly from N. to S., and facing Malabar; its north side extending E. and W. facing Mysore; and the remaining side extending from N.E. to S.W., towards the British district of Coimbatore. From the last-mentioned district, the Neilgherries rise in a vast precipitous mass to the height of from 5000 to 7000 feet, and the aggregate of the group is popularly divided into three ranges,—the Neddimullah on the N., the Koondah on the S., and the central or principal range, rising to the summit of Dodabetta, the highest in the group, and having an elevation of 8760 feet above the level of the sea, being the greatest in India south of the Himalaya. Owing to the great elevation of the various summits, and the consequent rarefaction of its atmosphere, the district, although distant only 11° from the equator, enjoys a climate famed for its salubrity, and the remarkable evenness of its seasons. The temperature, which falls in the coldest month of the year to the freezing point, seldom in the hottest reaches 75° in the shade. The great importance of this group lies in its sanatory stations for the re-establishment of health in those who have suffered from the heat of the climate in less elevated regions. The principal of these stations is Ootacamund, the two minor ones Coonoor and Kotageri. This tract of territory was transferred to the British on the downfall of Tippoo Sultan in 1799. (R. Baikie's *Neilgherries.*)

NEILSTON, a village and parish of Scotland, in the county of Renfrew, is situated on the Levern, 4 miles S. of Paisley, and 9 W.S.W. of Glasgow. It has an Established, a Free, and a United Presbyterian church, several schools, and a mechanics' institute. There are here also cotton-mills and bleachfields; and four fairs are held annually. Pop. (1851) of village, 2075; of parish, 12,233.

NEISSE, a town of Prussia, province of Silesia, on both sides of a river of the same name, 47 miles S.S.E. of Breslau. It is well built, surrounded by walls, and strongly fortified. There are three gates; and the town contains several fine public buildings. The episcopal palace is an ancient edifice, and is memorable for the meeting between Frederic II. and the Emperor Joseph II., which took place here in 1769. There are also two Protestant and several Roman Catholic churches, a grammar school, an industrial school, two hospitals, an establishment for superannuated

Nejin || Nelson.

Roman Catholic priests, large powder-mills, barracks, and arsenals. Cotton is manufactured here, and a considerable trade is carried on in yarn and building stone. A weekly market for yarn, and an annual fair, are held here. Pop. (1849), 17,164.

NEJIN, or NIESHIN, a town of Russia, in the government of Tchernigov, stands on the Oster, 49 miles S.E. of Tchernigov, and 475 S.W. of Moscow. It is well built, and surrounded by earthen ramparts; and contains a castle, a cathedral, numerous other churches, a convent, a school, and an hospital. There are manufactures of soap, leather, silks, perfumes, confectionary, *liqueurs*, &c. The town has also a considerable trade, the intercourse between the ports on the Baltic and Moldavia, Wallachia, and the Crimea being carried on through it. Three annual fairs are held here, and largely attended. Pop. (1849) 17,981.

NEKO, or NECHO, a king of Egypt who flourished in the fifth century B.C. (See EGYPT.)

NELLORE, in Hindustan, a town within the presidency of Madras, on the right bank of the River Penna, 18 miles from the spot where it falls into the Bay of Bengal. The town is irregularly built, and in places rather crowded and confined; but there are some good streets occupied by the better classes, and on the whole, for a native town, it is tolerably clean and airy. The population is estimated at 20,000; distant N. from Madras 100 miles; N. Lat. 14. 27., E. Long. 80. 2. The British district, of which this town is the chief place, is bounded on the N. by Guntoor, on the E. by the Bay of Bengal, on the S. by Arcot, and on the W. by Cuddapah. It lies between N. Lat. 13. 55. and 16., E. Long. 79. 8. and 80. 21. The area, according to official return, is 7930 square miles, and the population 935,690.

NELSON, HORATIO, Lord Viscount, the son of Edmund and Catherine Nelson, was born on the 29th of September 1758, at the parsonage-house of Burnham-Thorpe, a village in the county of Norfolk, of which his father was rector. The maiden name of his mother was Suckling; her grandmother was an elder sister of Sir Robert Walpole, and the subject of this notice was named after the first Earl of Orford. Mrs Nelson died in 1767, leaving eight out of eleven children. Upon this occasion her brother, Captain Maurice Suckling, of the navy, visited Mr Nelson, and promised to take care of one of the boys. Three years afterwards, when Horatio was only twelve years of age, and with a constitution naturally weak, he applied to his father for permission to go to sea with his uncle, recently appointed to the Raisonnable of sixty-four guns. The uncle was accordingly written to, and gave a reluctant consent to the proposal. "What," said he, in reply, "has poor Horatio done, who is so weak, that he should be sent to rough it out at sea? But let him come; and the first time we go into action a cannon-ball may knock off his head, and provide for him at once." The Raisonnable, on board of which he was now placed as a midshipman, was soon afterwards paid off, and Captain Suckling removed to the Triumph, of seventy-four guns, then stationed as a guard-ship in the Thames. This, however, was considered as too inactive a life for a boy, and Nelson was therefore sent a voyage to the West Indies in a merchant ship. "From this voyage I returned," he tells us in his *Sketch of my Life*, "to the Triumph at Chatham in July 1772; and if I did not improve in my education, I returned a practical seaman, with a horror of the royal navy, and with a saying then constant with the seamen, 'Aft, the most honour; forward, the better man.'" While in connection with this guardship, he had the opportunity of becoming a skilful pilot, an acquirement which he afterwards had frequent occasion to turn to account.

Not many months after his return, his inherent love of enterprise was excited by hearing that two ships were fitting out for a voyage of discovery towards the North Pole. From the difficulties expected on such service, these vessels were to take out none but effective men, instead of the usual number of boys. This, however, did not deter Nelson from soliciting to be received, and by his uncle's interest he was admitted as cockswain under Captain Lutwidge, the second in command. The voyage was undertaken in consequence of an application from the Royal Society; and the Honourable Captain John C. Phipps, eldest son of Lord Mulgrave, volunteered his services to command the expedition. The Racehorse and Carcass, bombs, were selected as the strongest ships, and the expedition sailed from the Nore on the 4th of June 1773, and returned to England in October. During this voyage Nelson gave several indications of that daring and fearless spirit which ever afterwards distinguished him.

Nelson.

The ships were paid off shortly after their return, and the youth was then placed by his uncle with Captain Farmer in the Seahorse, of twenty guns, which was about to sail for the East Indies in the squadron of Sir Edward Hughes. In this ship he was rated as a midshipman, and attracted attention by his general good conduct. But when he had been about eighteen months in India, he felt the effects of the climate of that country, so perilous to European constitutions, and became so enfeebled by disease that he lost for a time the use of his limbs, and was brought almost to the brink of the grave. He embarked for England in the Dolphin, Captain Pigot, with a body broken down by sickness, and spirits which had sunk with his strength. But his health materially improved during the voyage, and his native air speedily repaired the injury it had sustained. On the 8th of April 1777 he passed, with much credit to himself, his examination for a lieutenancy, and next day received his commission as second lieutenant of the Lowestoffe, of thirty-two guns, then fitting out for Jamaica. In this frigate he cruised against the American and French privateers which were at that time harassing our trade in the West Indies; distinguished himself on various occasions by his activity and enterprise; and formed a friendship with his captain, Locker, of the Lowestoffe, which continued during his life. Having been warmly recommended to Sir Peter Parker, the commander-in-chief upon that station, he was removed into the Bristol flag-ship, and soon afterwards became first lieutenant. On the 8th of December 1778 he was appointed commander of the Badger brig, in which he rendered important assistance in rescuing the crew of the Glasgow, when that ship was accidentally set on fire in Montego Bay, Jamaica. On the 11th of June 1779 he obtained the rank of post-captain, and with it the command of the Hinchinbrook of twenty-eight guns. As Count d'Estaing, with a fleet of 125 sail, men-of-war and transports, and a reputed force of 25,000 men, now threatened Jamaica from St Domingo, Nelson offered his services to the admiral and governor-general, Dalling, and was appointed to command the batteries of Fort-Charles at Port-Royal, the most important post in the island. D'Estaing, however, attempted nothing with this formidable armament, and the British general was thus left to execute a design which he had formed against the Spanish colonies. This project was to take Fort San Juan, situated upon the river of that name, which flows from Lake Nicaragua into the Gulf of Mexico; to make himself master of the lake itself, and of the cities of Granada and Leon; and thus to cut off the communication between the northern and southern possessions of Spain in America. Nelson was appointed to the command of the naval department, and distinguished himself greatly in the siege of Fort San Juan and in taking the island of St Bartolomeo. Pestilence, however, decimated the crew of the Hinchinbrook; and her gallant young commander, prostrated by sickness, was compelled to return to England. He was taken home in the Lyon, by Captain, afterwards

Nelson. Admiral, Cornwallis, to whose care and kindness he believed himself indebted for the preservation of his life. In three months, however, his health was so far re-established that he applied for employment; and being appointed to the Albemarle, of twenty-eight guns, he was sent to the North Seas, and kept there cruising during the whole winter, which he did not at all relish. In this cruise, however, he gained a considerable knowledge of the Danish coast and its soundings. On his return he was ordered to Quebec, and during the voyage the Albemarle had a narrow escape from four French sail of the line and a frigate, which, having come out of Boston, gave chase to her. Confiding in his own skill and pilotage, Nelson, perceiving that they gained on him, boldly ran among the numerous shoals of St George's Bank, and thus escaped. In October 1782 he sailed from Quebec with a convoy of transports for New York, where he joined Lord Hood, and accompanied him to the West Indies. At the peace of 1783, the Albemarle returned to England, and was paid off.

After his arrival in England, Nelson, finding it prudent to economize his half-pay during the peace, went to St Omer, where he remained till the spring of the following year. On his return, he was appointed to the Boreas, of twenty-eight guns, which had been ordered to the Leeward Islands as a cruiser. Whilst on this station, where he found himself senior captain, and consequently second in command, he evinced the utmost zeal and activity in protecting British interests, and in causing the Navigation Act to be respected, especially by the Americans, who had attempted, under various pretences, to establish an independent commerce with the West India Islands; a line of conduct which involved him in much trouble, without procuring him reward or even acknowledgment—the thanks of the Treasury having been transmitted to the commander-in-chief, who had thwarted instead of encouraging him in the discharge of an arduous and important duty. On the 11th of March 1787, Nelson married the widow of Dr Nisbet, a physician, and daughter of Herbert, the president of the island of Nevis. The Boreas returned to England in June, but was not paid off till the end of November, having been kept nearly five months at the Nore as a slop and receiving ship. Nelson was still in a very precarious state of health; and this treatment, whether proceeding from intention or neglect, excited in his mind the strongest indignation. His resentment, however, was appeased by the favourable reception which he met with at court, when presented to his Majesty by Lord Howe; and having fully explained to that nobleman the grounds upon which he had acted, he retired to enjoy the pleasures of domestic happiness at the parsonage-house at Burnham-Thorpe, which his father had given him as a residence. But the vexatious affair of the American captures was not yet terminated. He was harassed with threats of prosecution, and, in his absence on some business, a writ or notification was served on his wife, upon the part of the American captains, who now laid their damages at L.20,000. When presented with this paper, his indignation was excessive; and he immediately wrote to the Treasury, that unless he was supported by government he would leave the country. "If sixpence would save me from prosecution," said he, "I would not give it." The answer he received, however, quieted his fears; he was told to be under no apprehension, for he would assuredly be supported; and here his disquietude upon this subject seems to have ended.

At the commencement of the French war, it was judged expedient again to employ Nelson; and on the 30th of January 1793 he was appointed to the Agamemnon, of sixty-four guns, and placed under the orders of Lord Hood, then holding the chief command in the Mediterranean fleet. Being sent to Corsica with a small squadron, to co-operate with Paoli and the party opposed to France, he undertook the siege of Bastia, and in a short time reduced it. The place capitulated on the 19th of May 1794. He next proceeded in the Agamemnon to co-operate with General Sir Charles Stuart in the siege of Calvi. Here Nelson had less responsibility than at Bastia; he was acting with a man after his own heart, who slept every night in the advanced battery. Here Nelson received a serious injury. A shot having struck the ground near him, drove the sand and small gravel into one of his eyes. He spoke of it lightly at the time, and in fact suffered it to confine him only one day; but the sight of the eye was nevertheless lost. After the fall of Calvi his services were, by a strange omission, altogether overlooked, and his name was not even mentioned in the list of wounded. Nelson felt himself not only neglected, but wronged. "They have not done me justice," said he; "but never mind, I'll have a gazette of my own." And on another occasion the same second-sight of glory led him to predict that one day or other he would have a long gazette to himself. "I feel," said he, "that such an opportunity will be given me. If I am in the field of glory, I cannot be kept out of sight."

Nelson.

Lord Hood now returned to England, and the command devolved upon Admiral Hotham. Tuscany had now concluded peace with France; Corsica was in danger; Genoa was threatened; and the French, who had not yet been taught to feel their inferiority upon the seas, openly braved us on that element. Having a superior fleet in the Mediterranean, they now sent it out with express orders to seek the English and engage them. In the action which followed between the English fleet under Admiral Hotham, and that which had come out from Toulon, Nelson greatly distinguished himself, manœuvring and fighting his ship with equal ability and determination; and when the action was renewed the following day, he had the honour of hoisting the English colours on board of the Ça Ira and the Censeur, which both struck to him, and were the only ships of the enemy taken on that occasion.[1] About this time Nelson was made colonel of marines, a mark of approbation which he had rather wished for than expected; and soon afterwards the Agamemnon was ordered to Genoa to co-operate with the Austrian and Sardinian forces. This was indeed a new line of service, imposing multifarious duties, and involving great responsibility; yet it was also one for which Nelson had already evinced a singular aptitude, and in which, had he been at all seconded by the land forces, his assistance would have led to important results. Through the gross misconduct, however, of the Austrian general, Devins, the allies were completely defeated by an army of boys, and the French obtained possession of the Genoese coast from Savona to Voltri, thus intercepting the direct communication between the Austrian army and the English fleet. After this disgraceful affair, the Agamemnon was recalled, and sailed for Leghorn to refit, being literally riddled with shot, and having all her masts and yards seriously damaged.

Sir John Jervis having arrived to take the command in the Mediterranean, Nelson sailed from Leghorn in the Agamemnon, which had now been repaired, and joined the admiral in St Fiorenzo Bay. When the French took possession of Leghorn, he blockaded that port, and landed a force in the Isle of Elba to secure Porto Ferrajo. Soon

[1] Nelson urged the admiral to pursue the enemy, and follow up his advantage to the utmost; but the latter replied, "We must be contented; we have done very well." The captain of the Agamemnon did not understand such timid reasoning. "Had we taken ten sail," said he, "and allowed the eleventh to escape when it had been possible to have got at her, I could never have called it well done." He adds, that if his advice had been followed, they would have had such a day as the annals of England never produced.

Nelson. afterwards he took the island of Capraja; and the British cabinet having resolved to evacuate Corsica, he ably performed this humiliating service. He was then ordered to hoist his broad pennant on board of the Minerve frigate, Captain George Cockburn, and to proceed with the Blanche to Porto Ferrajo, and bring away the troops and stores left at that place. On his way thither he fell in with two Spanish frigates, the Sabina and Ceres, the former of which, after an action of three hours, during which the Spaniards lost 164 men, struck to the Minerve. The Ceres, however, had got off from the Blanche; and as the prisoners had hardly been conveyed on board of the Minerve when another enemy's frigate came up, Nelson was compelled to cast off the prize and go a second time into action. But after a short trial of strength, this new antagonist wore and hauled off; and as a Spanish squadron of two sail of the line and two frigates now came in sight, the commodore made all sail for Porto Ferrajo, whence he soon returned with a convoy to Gibraltar. Off the mouth of the Straits he fell in with the Spanish fleet, and reaching the station off Cape St Vincent on the 13th of February 1797, he communicated this intelligence to Sir John Jervis, by whom he was now directed to shift his broad pennant on board the Captain, of seventy-four guns. Before sunset the signal was made to prepare for action, and to keep in close order during the night; and at daybreak on the 14th the enemy were in sight. The British force consisted of two ships of 100 guns, two of 98, two of 90, eight of 74, and one of 64, with four frigates, a sloop, and a cutter; the Spaniards had one ship of 136 guns, six of 112 guns each, two of 84, and eighteen of 74, with ten frigates and a brig. The admiral, Sir John Jervis, made signal to tack in succession. Nelson, whose station was in the rear of the British line, perceiving that the Spaniards were bearing up before the wind, with an intention of forming line and joining their separated ships, or of avoiding an engagement, disobeyed the signal without a moment's hesitation, and ordered his ship to be wore. This at once brought him into action with seven of the enemy's ships, four of which were first-rates. After a desperate conflict, in which Nelson was nobly supported by Troubridge in the Culloden and by Collingwood in the Excellent, the Salvador del Mundo and San Isidro dropped astern, and the San Josef fell on board the San Nicolas. The Captain being now incapable of further service, either in the line or in chase, Nelson directed the helm to be put a-starboard, and calling the boarders, ordered them to board. The San Nicolas was carried after a short struggle, Nelson himself boarding her through the cabin windows. The San Josef was instantly boarded from the San Nicolas, the gallant little commodore leading the way, and exclaiming, "Westminster Abbey or victory!" This was the work of an instant; but before Nelson could reach the quarter-deck of the Spanish ship, an officer looked over the rail and said they surrendered. This daring achievement was effected with comparatively small loss, and Nelson himself received only a few bruises. The Captain, however, had suffered severely in the action. She had lost her fore-topmast; not a sail, shroud, nor rope was left; her wheel had been shot away; and a fourth part of the loss sustained by the whole squadron had fallen upon that single ship. As soon as the action was discontinued, Nelson went on board the admiral's ship. Sir John Jervis received him with open arms, and said he could not sufficiently thank him. For this victory the commander-in-chief was rewarded with a peerage and the title of Earl St Vincent; whilst Nelson, who, before the action was known in England, had been advanced to the rank of rear-admiral, was knighted, and received the insignia of the Bath, and a gold medal from his sovereign. Nelson.

In April 1797 Sir Horatio Nelson, having hoisted his flag as rear-admiral of the blue, was sent to bring away the troops from Porto Ferrajo; and having performed this service, he shifted his flag to the Theseus, a ship which had taken part in the mutiny in England. Whilst in the Theseus he was employed in the command of the inner squadron at the blockade of Cadiz. During this service his personal courage was eminently signalized. In a night attack upon the Spanish gun-boats (3d July 1797), his barge was assailed by an armed launch, carrying twenty-six men, whilst he had with him only the usual complement of ten men and the cockswain, besides Captain Freemantle. After a severe conflict, hand to hand, eighteen of the enemy were killed, all the rest wounded, and the launch taken. Twelve days after this rencontre, Nelson sailed at the head of an expedition against Teneriffe. It having been ascertained that a homeward-bound Manilla ship had recently put into Santa Cruz, the expedition was undertaken in the hope of capturing this rich prize. But it was not fitted out upon the scale which Nelson had proposed; no troops were embarked; and although the attack was made with great intrepidity, the attempt failed. The boats of the squadron being manned, a landing was effected early in the night, and Santa Cruz taken and occupied for about seven hours; but the assailants, finding it impracticable to storm the citadel, were obliged to prepare for retreat, which they effected without molestation, agreeably to stipulations which had been made with the Spanish governor by Captain Troubridge, whose firmness and presence of mind were conspicuously displayed on this occasion. The total loss of the English in killed, wounded, and drowned, amounted to 250. Nelson himself was amongst the wounded, having, in stepping out of the boat to land, received a shot through the right elbow, which shattered the whole arm, and rendered amputation necessary. Nelson was now obliged to return to England, where honours awaited him sufficient to cheer his mind amidst the sufferings occasioned by the loss of his arm. Letters were addressed to him by the first lord of the Admiralty and the Duke of Clarence; the freedom of the cities of London and Bristol was transmitted to him; he was invested with the Order of the Bath; and he also received a pension of L.1000 a year.[1] His sufferings from the lost limb, however, were long and painful. In April 1798 he had so far recovered, however, as to hoist his flag on board the Vanguard, and was ordered to rejoin Earl St Vincent. Immediately on his arrival, he was despatched to the Mediterranean with a small squadron, to ascertain, if possible, the object of the great expedition which was then fitting out at Toulon. He sailed from Gibraltar on the 9th of May for the Mediterranean, with three seventy-fours, four frigates, and a sloop of war. On the 19th the squadron reached the Gulf of Lyons; and on the 22d a violent storm inflicted very serious injury on the Vanguard; but after extraordinary exertions, the Vanguard was refitted in four

[1] The memorial which, as a matter of course, he was called upon to present on this occasion, exhibited an extraordinary catalogue of services performed during the war. It is dated "October 1797," and addressed "to the King's most excellent Majesty." It stated, that he had been in four actions with the fleets of the enemy, and in three actions with frigates, in six engagements against batteries, in ten actions in boats employed in cutting vessels out of harbour or in destroying them, and in taking three towns; that he had served on shore with the army four months, and commanded the batteries at the sieges of Bastia and Calvi; that he had assisted at the capture of seven sail of the line, six frigates, four corvettes, and eleven privateers of different sizes; that he had taken and destroyed nearly fifty sail of merchant-vessels, and had actually been engaged against the enemy upwards of one hundred and twenty times; in which services he had lost his right eye and right arm, and had been severely wounded and bruised in his body. This memorial alone, apart from the splendid additions which he afterwards made to it, is perhaps without a parallel in our naval history.

Nelson. days, and he received a reinforcement of ten ships of the line and one of fifty guns, under the command of Commodore Troubridge. Baffled in his attempts to get sight of the French fleet, he kept scouring the Mediterranean waters under a press of sail night and day for nearly two months, till, on the 1st of August 1798, he came in sight of Alexandria, and at four in the afternoon descried the French fleet. For several days previous to this the admiral had scarcely taken either food or sleep. He now ordered his dinner to be served, whilst preparations were making for battle; and when his officers rose from table to repair to their several stations, he said to them, "Before this time to-morrow I shall have gained a peerage, or Westminster Abbey."

Brueys, the admiral of the French fleet, had moored his ships in Aboukir Bay, in a strong and compact line of battle; the headmost vessel being close to a shoal on the north-west, and the rest of the fleet forming a kind of curve along the line of deep water, so as not to be turned by any means on the south-west. The advantage of numbers, both in ships, guns, and men, was in favour of the French. They had thirteen ships of the line and four frigates, carrying 1196 guns, and 11,230 men. The English had the same number of ships of the line, and one 50-gun ship, carrying in all 1012 guns and 8068 men. The English ships were all seventy-fours; the French had three 80-gun ships, and one three-decker of 120 guns. Nelson, according to the preconceived plan of attack, resolved to keep entirely on the outer side of the French line, and to station his ships, as far as he was able, one on the outer bow, and another on the outer quarter, of each of the enemy's, thus doubling on a certain portion of their line.[1] The battle commenced at half-past six o'clock, a little before sunset. As the squadron advanced, the enemy opened a steady fire from the starboard side of their line into the bows of the leading British ships. It was received in silence, whilst the men on board of each ship were employed aloft in furling the sails, and below in tending the braces and making ready for anchoring; a proceeding which told the enemy that escape was impossible. Four ships of the British squadron, having been detached previously to the discovery of the French fleet, were at a considerable distance when the battle commenced, and on coming up, the Culloden, the foremost of these ships, suddenly grounded in the darkness, and, notwithstanding the greatest exertions, could not be got off in time to bear a part in the action. The first two ships of the French line had been dismasted within a quarter of an hour after the commencement of the action; and the others had suffered so severely that victory was already certain. At half-past eight o'clock the third, fourth, and fifth were taken possession of. In the meantime Nelson had received a severe wound on the head from a langridge shot, which cut a large flap of skin from the forehead, and occasioned such an effusion of blood that the injury was at first believed to be mortal. But when the surgeon came to examine the wound, he found that the hurt was merely superficial, and requested that the admiral would remain quiet. Nelson, however, could not rest, and having called for his secretary, had begun to dictate his despatches, when suddenly a cry was heard upon deck that L'Orient was on fire. In the confusion, he found his way up unassisted and unnoticed, and having appeared on the quarter-deck, immediately gave orders that boats should be sent to the relief of the enemy. It was about ten minutes after nine o'clock when the fire broke out in L'Orient. Brueys was dead. He had received three wounds, yet would not leave his post; and when a fourth cut him almost in two, he desired to be left to die upon deck. In the meanwhile the flames soon mastered the devoted ship, and by the light of the conflagration, the situation of both fleets could be perceived, their colours being clearly distinguishable. About ten o'clock the ship blew up with a tremendous explosion, which was followed by a pause not less awful. The firing immediately ceased; and the first sound which broke the silence was the dash of her shattered masts and yards falling into the water from the vast height to which they had been projected by the explosion.[2] The combat recommenced with the ships to leeward of the centre, and continued till about three in the morning. Of thirteen sail of the line, nine were taken, two burnt, and two escaped; and of four frigates, one was burnt and another sunk. In short, it was a conquest rather than a victory. The French fleet had been annihilated; and if the English admiral had been provided with small craft, nothing could have prevented the destruction of the store-ships and transports in the harbour of Alexandria. Nelson.

Nelson was now at the very summit of glory. Congratulations, rewards, and honours were showered upon him by all the foreign states and powers to which his victory promised a respite from French aggression. In his own country he was created Baron Nelson of the Nile and of Burnham-Thorpe, with a pension of L.2000 a year for his own life and those of his two immediate successors. A grant of L.10,000 was voted to Nelson by the East India Company; the Turkish company presented him with a piece of plate; the city of London bestowed honorary swords on the admiral and his captains; and the thanks of the Parliament and gold medals were voted to him and to all the captains engaged in the action. In the distribution of rewards he was particularly anxious that the captain and first lieutenant of the Culloden should not be passed over because of their misfortune. "It was Troubridge," said he, in addressing the Admiralty, "who equipped the squadron so soon at Syracuse; it was Troubridge who exerted himself for me, after the action; it was Troubridge who saved the Culloden, where none that I know in the service would have attempted it."

Having made the necessary arrangements in regard to the prizes, and left a squadron before Alexandria, Nelson stood out to sea on the seventeenth day after the battle, and early on the 22d of September appeared in sight of Naples, where the Culloden and Alexander had preceded him, and given notice of his approach. Here he was received with every demonstration of joy and triumph, both by the royal family and the people; and it was here he formed that unfortunate connection with Lady Hamilton which exercised so baneful an influence on the rest of his life. The state of Naples at this period was deplorable. The king, like the rest of his race, was passionately fond of field sports, and cared for almost nothing else. The queen had all the vices of the House of Austria, with little to mitigate and nothing to ennoble them. The people were sunk in ignorance, and debased by misgovernment; at once turbulent and cowardly, ferocious and indolent, irreligious and fanatical. Nelson was fully sensible of the depravity and weakness of all by whom he was surrounded; yet, seduced by the blandishments of the queen, the flatteries of the court, and the pernicious

[1] A claim has been more than once put forward on behalf of Captain Foley of the Goliath (afterwards Admiral Sir Thomas Foley, G.C.B.), as having the merit of suggesting this mode of attack; but after carefully examining the evidence brought forward in support of this claim, Sir N. Harris Nicolas, in his edition of Nelson's *Dispatches*, vol. iii., p. 62, &c., is inclined to think that it is unfounded.

[2] To remind the sea-king of his mortality amid the torrents of praise and adulation which were poured upon him after the victory, an eccentric idea occurred to Captain Hallowell of the Swiftsure, of presenting his chief with a coffin made of part of L'Orient's mainmast. Nelson set great store by this present, and was actually buried, as the gallant captain of the Swiftsure desired, "in one of his own trophies." (Nelson's *Dispatches*, &c., by Sir N. H. Nicolas, vol. iii., p. 88, &c.)

Nelson. influence which Lady Hamilton now began to exercise over his mind, he suffered himself to be implicated in transactions which, to say the least of it, were not calculated to bring honour to his country, or to heighten his own fame. The defeat of Mack at Castellana, and the advance of the French towards Naples, were followed by the flight of the royal family, who were conveyed by Nelson to Palermo. After this an armistice was signed (10th of January 1799), by which the greater part of the kingdom was given up to the enemy; and this cession necessarily led to the loss of the whole. Naples was occupied by the French under Championnet, and the short-lived Parthenopean republic soon afterwards established. But the successes of the allies in Italy speedily changed the face of affairs, and prepared the way for the restoration of the exiled monarch.

Relying on the diminished numbers of the enemy, whose force had been greatly reduced, the royalists took the field, and Cardinal Ruffo appeared at the head of an armed rabble, which he called the Christian army. Captain Foote, in the Seahorse, with some Neapolitan frigates, and a few smaller vessels, was ordered to co-operate with this force, and to give it all the assistance in his power. Ruffo, advancing without any plan, but ready to take advantage of any accident which might occur, now approached Naples. Fort St Elmo, which commands the city, was garrisoned by French troops; but the castles of Uovo and Nuovo, commanding the anchorage, were chiefly defended by the Neapolitan "patriots," the leading men amongst them having taken shelter there. As the possession of these castles would greatly facilitate the reduction of Fort St Elmo, Ruffo proposed to the garrison to capitulate, on condition that their persons and property should be respected, and that they should at their own option, either be sent to Toulon or remain at Naples, without being molested in their persons. These terms were accepted, and the capitulation was signed by the cardinal, the Russian and Turkish commanders, and also by Captain Foote as commanding the British force. But Nelson, who soon afterwards arrived in the bay with a large fleet, made a signal to annul the treaty, declaring that he would grant to rebels no other terms than those of unconditional submission; and notwithstanding the strenuous opposition of the cardinal, the garrisons of the castles were delivered over as rebels to the vengeance of the Sicilian court. This questionable transaction was followed by the execution of Caraccioli. This aged prince, a man who hitherto had borne a high character, and who was a commodore in the Neapolitan navy, had, from some motive or other, joined the enemy; and after being tried by a court-martial of Neapolitan officers, assembled on board the British flag-ship, was found guilty, and sentenced to death. This sentence Lord Nelson ordered to be carried into execution the same evening, on board of the Sicilian frigate La Minerva. As a reward for these services, which have, in the judgment of many, left a blot on the scutcheon of the great admiral, Nelson received from the Sicilian court a sword splendidly enriched with diamonds, in addition to the dukedom of Bronté, with a domain worth about L.3000 a year.[1] Nelson.

After the appointment of Lord Keith to the chief command of the fleet in the Mediterranean, Nelson was so deeply mortified that he made preparations for his return to England; and, as a ship could not be spared to convey him thither, he travelled through Germany to Hamburg, in company with Sir William and Lady Hamilton, and having embarked at Cuxhaven, landed at Yarmouth on the 6th of November 1800, after an absence of three years from his native country. He was welcomed in England with every mark of popular respect and admiration; in the towns through which he passed the people came out to meet him, and in London he was feasted by the city, drawn by the populace, thanked for his victory by the Common Council, and presented with a gold-hilted sword studded with diamonds. He had now every earthly blessing except domestic happiness, which, in consequence of his infatuated attachment to Lady Hamilton, he had forfeited for ever. Before he had been three months in England he separated from Lady Nelson, after much uneasiness and recrimination on both sides. On taking final leave of her, on 13th January 1801, he emphatically said "I call God to witness there is nothing in you or your conduct I wish otherwise." His best friends remonstrated against this causeless and cruel desertion; but their expostulations produced no other effect than to make him displeased with them, and dissatisfied with himself.

The three northern courts of Denmark, Sweden, and Russia, had now formed a confederacy for the purpose of setting limits to the naval pretensions of Great Britain; and as such a combination, under the influence of France, would soon have become formidable, the British cabinet instantly prepared to crush it. With this view a formidable fleet was fitted out for the North Seas, and the chief command of it given to Sir Hyde Parker; under whom Nelson, who had recently been made vice-admiral of the blue, consented to serve as second in command. The fleet sailed from Yarmouth on the 12th of March 1801; and on the 30th of the same month, Lord Nelson, having shifted his flag from the St George to the Elephant, led the way through the Sound, which was passed without any loss. The Danes had made every preparation for a determined resistance. Besides, the navigation was little known and extremely intricate; all the buoys had been removed; the channel was considered as impracticable for so large a fleet; and in a council of war, held on board of the flag-ship, considerable diversity of opinion prevailed. Nelson, however, cut short the discussion by offering his services for the attack, requiring only ten sail of the line and the whole of the smaller craft. Sir Hyde Parker assented, but gave him two more line-of-battle ships than he had asked, and left everything to his own judgment. On the morning of the 1st of April, the whole fleet moved to an anchorage within two leagues of the town; and about one o'clock Nelson, having completed his last examination of the ground, made the signal to weigh,

[1] In connection with this whole matter, the heaviest accusations have been again and again brought against Nelson. He has been accused of "treachery," in annulling the treaty of capitulation, and of "murder" in the execution of Franceso Caraccioli. The entire question has been subjected to a minute and careful examination by Sir N. Harris Nicolas, in an Appendix to the third volume of his edition of Nelson's *Dispatches*, where he endeavours to mitigate or remove the weighty charges brought against the brave admiral. The impression left upon the mind of the reader by the vast amount of evidence therein accumulated is, that while Nelson was possibly wrong in suspending the capitulation, even although its conditions were not executed, nevertheless, "the intentions and motives," to use the words of Lord Spencer, then first lord of the Admiralty, and a statesman of great humanity of character, "by which all his measures were governed, were as pure and good as their success was complete." Nelson believed at the time that he acted correctly, and retained the same opinion to the end of his life. It must, however, continue to be deeply regretted that he should have seen it his duty to suspend the treaty, as often as the dark consequences are contemplated which ensued after the rebels were handed over to the Neapolitan authorities. With respect, again, to the execution of the old Neapolitan commodore, who commanded the republican gunboats, and fired upon the Neapolitan frigate, Sir Harris pronounces it as his deliberate opinion, in view of all the evidence of the case, that "it is indisputable that Caraccioli, and the other Neapolitans who fought against those forces, had, according to the law of every nation in Europe, committed *high treason* of a flagrant description, and that they were consequently *rebels*." The *justice* of the sentence was therefore unquestionable; and the question of *humanity* could only be fairly pronounced upon by those who know the entire circumstances in which Nelson was placed.

Nelson. which was received with a shout throughout the whole division destined for the attack. They weighed with a light and favourable wind, the small craft pointing out the course to be followed; and the whole division, having coasted along the shoal called the Middle Ground, doubled its farther extremity, and anchored there just as the darkness closed, the signal to prepare for action having been made early in the evening. As his anchor dropped, Nelson exclaimed, "I will fight them the moment I have a fair wind."

On the following morning, at half-past nine, the signal was made for the ships to weigh in succession; at ten minutes after ten the action commenced, at the distance of about half a cable length from the enemy; and by half-past eleven the battle became general. The plan of attack had been complete; but seldom had any project of the kind been disconcerted by more untoward accidents. Three of the ships had grounded, and only one gun-brig and two bomb-vessels could be got fairly into action. Nelson's agitation was extreme when he found himself, before the action began, deprived of a fourth part of his force; but no sooner was he in action than the wild music of the fight seemed to drive away all anxious thoughts; his countenance brightened, and his conversation became joyous, animated, and delightful. At one o'clock the enemy's fire continued unslackened; and the commander-in-chief, despairing of success, made the signal for discontinuing the action. At this moment, whilst Nelson was pacing the quarter-deck in all the excitement of battle, a shot passing through the main-mast, knocked the splinters about. "It is warm work," said he, "and this day may be the last to any of us at a moment; but, mark you," he added, "I would not be elsewhere for thousands." The signal-lieutenant now called out that the signal for discontinuing the action had been thrown out by the commander-in-chief. Nelson continued to walk the deck, and appeared not to notice it. At the next turn, the lieutenant asked if he should repeat the signal. "No," replied Nelson; "acknowledge it." He then called to know if the signal for close action was still hoisted; and being answered in the affirmative, said, "Mind you keep it so." A little after, "I have a right to be blind sometimes, Foley," added he, addressing the captain; then putting the glass to his blind eye, in a mood of sportive bitterness, which gives an inexpressible interest to the scene, "I really do not see the signal," he exclaimed; and after a pause, "Keep mine for closer battle flying; that's the way I answer such signals; nail mine to the mast."

Between one and two o'clock, however, the fire of the Danes slackened: by half-past two the action had ceased, except with the Crown batteries, and one or two ships which had renewed their fire, though with but little effect. At this critical moment, Nelson, with his accustomed presence of mind, resolved to secure the advantage he had gained, and to open a negotiation. He retired into the stern gallery, and wrote to the Crown Prince thus: "Vice-Admiral Lord Nelson has been commanded to spare Denmark when she no longer resists. The line of defence which covered her shores has struck to the British flag;—but if the firing is continued on the part of Denmark, he must set on fire all the prizes he has taken, without having the power of saving the men who have so nobly defended them. The brave Danes are the brothers, and should never be the enemies, of the English." This, after an interchange of communications, led to an interview between Nelson and the Crown Prince, at which the preliminaries of negotiations were adjusted; and a treaty was at length concluded, by which the northern confederacy was dissolved, and the maritime superiority of Britain unequivocally recognised. For the battle of Copenhagen, Nelson was raised to the rank of viscount, and, on the recall of Sir Hyde Parker, appointed to the chief command in the North Sea. His complaints in his correspondence (vol. iv. of *Dispatches and Letters*) are loud and indignant, however, that the gallantry of his captains had not, as after other great battles, been rewarded with medals, and that the city of London had withheld its thanks from those who won that brilliant victory. "I long to have the medal for Copenhagen," he said, "which I would not give up to be made an English duke." But the medal never came. Nelson.

Having settled affairs in the Baltic, Lord Nelson returned in a frigate to England. But he had not been many weeks ashore when he was called upon to attack the flotilla which had been prepared at Boulogne for the threatened invasion of England. The enemy were fully prepared, however, and though nothing could exceed the gallantry with which they were assailed, the enterprise proved unsuccessful. He now desired to be relieved from this boat-service, thinking it an unsuitable employment for a vice-admiral; and his wishes were speedily gratified by the signature of the preliminaries of peace.

He had purchased a house and an estate at Merton in Surrey, meaning to pass there the remainder of his days, in the society of Sir William and Lady Hamilton. But the happiness which he had promised himself was not of long continuance. Sir William Hamilton died early in 1803. A few weeks subsequent to this event the war was renewed; and the day after his Majesty's message to Parliament, announcing the recommencement of hostilities, Lord Nelson departed to assume the command of the fleet in the Mediterranean.

On the 20th of May 1803, he hoisted his flag on board the Victory, and having taken his station immediately off Toulon, he there waited with incessant watchfulness for the coming out of the enemy. This blockade proved one of the longest and most persevering that have been recorded in our naval annals; yet notwithstanding all his vigilance, the Toulon fleet put to sea on the 18th of January 1805, and shortly afterwards formed a junction with the Spanish squadron at Cadiz; Sir John Orde, who commanded off that port, having retired at their approach. Nelson had formed his own judgment of their destination, when Donald Campbell, then an admiral in the Portuguese service, went on board of the Victory, and communicated his certain knowledge that the combined French and Spanish fleets were bound for the West Indies. The enemy had five and thirty days' start; but Nelson calculated that he should gain eight or ten days by his exertions. To the West Indies therefore he bent all sail with his ten ships, in eager pursuit of eighteen, and on the 4th of June reached Barbadoes, whither he had sent despatches before him. Deceived by false intelligence, he then stood to the southward in quest of the enemy; but advices having met him by the way that the combined fleets were at Martinique, he immediately sailed for that island, where he arrived on the 9th, and received certain intelligence that they had passed to the leeward of Antigua the preceding day, and taken a homeward-bound convoy. It was now clear that the enemy, having accomplished the object of their cruise, were flying back to Europe; and accordingly, on the 13th, he steered for Europe in pursuit of them. On the 17th July he came in sight of Cape St Vincent, and directed his course towards Gibraltar, where he soon afterwards anchored, and went on shore for the first time since the 16th of June 1803. The combined fleet having thus eluded his pursuit, he returned almost inconsolable to England, to reinforce the Channel fleet with his squadron, lest the enemy should bear down upon Brest with their whole collected force.

Having landed at Portsmouth, Lord Nelson at length received news of the enemy's fleet. After an inconclusive action, in which they had run the gauntlet through Sir Robert Calder's squadron on the 22d of July, about 60 leagues west of Cape Finisterre, they had proceeded to Ferrol, brought out the squadron which there awaited their

Nelson. arrival, and with it entered Cadiz in safety. Upon receiving this intelligence, Nelson again offered his services, which were willingly accepted; and Lord Barham, then at the head of the Admiralty, gave him a list of the navy, desiring him to choose his own officers. No appointment could be more in unison with the feelings and judgment of the nation. The Victory, destined once more to bear his flag, was refitted with incredible despatch; and such was his impatience to be at the scene of action, that although the wind proved adverse, he worked down the Channel, and, after a rough passage, arrived off Cadiz on the 29th of September, the day on which the French admiral, Villeneuve, had received peremptory orders to put to sea the very first opportunity. Fearing that the enemy, if they knew his force, might be deterred from venturing to sea, he kept out of sight of land; desired Collingwood to hoist no colours, and fire no salute; and wrote to Gibraltar to request that the force of the fleet might not be inserted in the gazette published there. The station which he chose was some 50 or 60 miles to the westward of Cadiz, off Cape St Mary's.

On the 9th of October Lord Nelson communicated to Admiral Collingwood his plan of attack. The order of sailing was to be the order of battle. His object he declared to be close and decisive action. "In case signals cannot be seen or clearly understood," said he, "no captain can do wrong if he place his ship alongside that of an enemy." This was what he called the *Nelson-touch*. It was a mode of attack equally new and simple. Every one comprehended it in a moment, and was convinced that it would succeed. In fact, it proved irresistible.

Villeneuve, relying upon the information he had received, put to sea on the 19th, and at daybreak, on the 21st of October 1805, the combined fleets were distinctly seen from the deck of the Victory, formed in a close line ahead, about 12 miles to the leeward, and standing to the southward, off Cape Trafalgar. The British fleet consisted of 27 sail of the line and 4 frigates; the enemy's fleet of 33 sail of the line and 7 frigates. But their superiority was greater in size and in weight of metal than in numbers; they had 4000 troops on board; and the best riflemen who could be procured, many of them Tyrolese, were dispersed throughout the ships. Soon after daylight Nelson came on deck, and the signal was made to bear down on the enemy in two lines, upon which the fleet set all sail; Collingwood, in the Royal Sovereign, leading the lee line of 13 ships, and Nelson, in the Victory, leading the weather line of 14. Having seen that all was right, he retired to his cabin, and wrote a devout prayer, in which, after beseeching the Almighty to grant a great and glorious victory, he committed his life to the God of Battles; and in another writing which he annexed in the same diary, he bequeathed Lady Hamilton as a legacy to his king and country, and commended to the public beneficence his adopted daughter, Horatia, desiring that in future she would use the name of Nelson only. Blackwood went on board the Victory about six, and found him in good spirits, but very calm, and with none of that exhilaration which he had displayed on entering into battle at Aboukir and at Copenhagen. With a prophetic anticipation, he seems to have looked for death with almost as certain a conviction as for victory. His whole attention was fixed upon the enemy, who now formed their line with much skill on the larboard tack. Then appeared that signal—Nelson's last signal—which will be remembered as long as the language or even the memory of England shall endure:—"England expects every man to do his duty." It was received throughout the fleet with a responsive burst of acclamation, rendered sublime by the spirit which it breathed, and the determination it expressed. "Now," said Nelson, "I can do no more. We must trust to the great disposer of all events, and the justice of our cause. I thank God for this great opportunity of doing my duty."

On this memorable day Nelson wore, as usual, his admiral's frock-coat, bearing upon the left breast the various orders with which he had at different times been invested. Decorations which rendered him so conspicuous a mark to the enemy were beheld with ominous apprehension by his officers, especially as it was known that there were riflemen on board the French ships, and it could not be doubted that his life would be particularly aimed at. This was a point, however, on which it was hopeless to reason or remonstrate with him. "In honour I gained them," said he, when allusion was made to the insignia he wore, "and in honour I will die with them." Nevertheless, Captain Blackwood, and his own captain, Hardy, having represented to him how advantageous it would be to the fleet were he to keep out of action as long as possible, he consented that the Temeraire and the Leviathan, which were sailing abreast of the Victory should be ordered to pass ahead. But the order was unavailing; for these ships could not pass ahead if the Victory continued to carry all her sail; yet, so far from shortening sail, Nelson took an evident pleasure in pressing on, and rendering it impossible for them to obey his own order. As the enemy showed no colours till late in the action, the Santissima Trinidad was distinguishable only by her four decks; and to the bow of his old opponent in the action off Cape St Vincent he ordered the Victory to be steered. In the meantime, an incessant raking fire was kept up on the Victory; and as the ship approached, Nelson remarked, "This is too warm work to last long." She had not yet returned a single gun, though by this time fifty of her men had been killed or wounded, and her main-top-mast, with all her studding-sails and booms, shot away. A few minutes after 12, however, she opened her fire from both sides of her deck, and soon afterwards ran on board the Redoubtable, just as her tiller ropes were shot away. Captain Harvey, in the Temeraire, fell on board the Redoubtable on the other side; and another enemy's ship, the Fougueux, fell on board the Temeraire; so that these four ships formed as compact a tier as if they had been moored together, their heads lying all the same way. The lieutenants of the Victory now depressed their guns, and fired with a diminished charge, lest the shot should pass through and injure the Temeraire; and as there was danger that the Redoubtable might take fire from the lower-deck guns, the muzzles of which, when run out, touched her sides, the fireman of each gun stood ready with a bucket of water, which, as soon as the gun had been discharged, he dashed into the hole made by the shot. In this situation, the Victory kept up an incessant fire from both sides, directing her larboard guns on the Bucentaur and Santissima Trinidad.

Nelson.

But Nelson's hour was now come. It had been part of his prayer that the British fleet might be as distinguished for humanity in victory as for bravery in battle. Setting an example himself, he twice gave orders to cease firing upon the Redoubtable, supposing she had struck, because her great guns were silent; for as she carried no flag, it was impossible instantly to ascertain the fact. From the ship which he had thus twice spared he received his death-wound. In the heat of the action, about a quarter after one o'clock, a musket-ball from the mizen-top of the Redoubtable struck the epaulette on his left shoulder; and he fell upon his face on the spot covered with the blood of his secretary, Mr Scott, who had been killed a short time before. "They have done for me at last, Hardy," said he, as a serjeant of marines and two seamen raised him from the deck. "I hope not," replied Captain Hardy. "Yes," he rejoined; "my back bone is shot through." But, though mortally wounded, he did not for a moment lose that presence of mind for which he was ever distinguished. As they were carrying him down the ladder to the cockpit, he observed that the tiller ropes, which had been shot away

Nelson.

early in the action, were not yet replaced, and ordered that new ones should be immediately rove. He was laid upon a pallet in the midshipman's berth, and the surgeon being called, it was soon perceived that the wound he had received would speedily prove mortal; but this was concealed from all except Captain Hardy, the chaplain, and the medical attendants. Being certain, however, from the sensation which he felt in his back, and the gush of blood within his breast, that no human aid could avail him, he insisted that the surgeon should leave him, and attend to those to whom he might be useful. "You can do nothing for me," said he. Suffering from intense thirst, and in great pain, he expressed much anxiety as to the fate of the action; and his countenance brightened with a gleam of joy as often as the hurrah of the crew of the Victory announced that an enemy's ship had struck.

At length he became very impatient to see Captain Hardy, whom he repeatedly sent for; but that officer could not leave the deck, and upwards of an hour elapsed before he could quit his station. When they met, they shook hands in silence, Hardy struggling to suppress his emotions. "Well, Hardy," said Nelson, "how goes the day with us?" "Very well," replied the captain; "ten ships have struck, but five of the enemy's van have tacked, and show an intention of bearing down on the Victory. I have called two or three of our fresh ships round, and have no doubt of giving them a drubbing." "I hope," said Nelson, "none of our ships have struck." "There is no fear of that," answered Hardy; upon which the dying hero said, "I am a dead man: I am going fast; it will soon be all over with me; my back is shot through." Hardy, unable any longer to suppress his feelings, hastened upon deck; but in some fifty minutes, returned, and taking the hand of his dying commander, congratulated him on having gained a complete victory. He did not know how many of the enemy had struck, as it was impossible to perceive them distinctly; but fourteen or fifteen at least had surrendered. "That's well," answered Nelson; "but I had bargained for twenty." Then, in a stronger voice, he said, "Anchor, Hardy, anchor;" and again, most earnestly, "Do you anchor." Next to his country, Lady Hamilton occupied his thoughts. "Take care of my dear Lady Hamilton, Hardy; take care of poor Lady Hamilton;" and, a few minutes before he expired, he said to the chaplain, "Remember that I leave Lady Hamilton and my daughter Horatia as a legacy to my country." The last words he was heard to utter distinctly were, "I thank God, I have done my duty." He expired at half-past four o'clock, three hours and a quarter after he had received his fatal wound.

The total loss of the British in the battle of Trafalgar amounted to 1587. Twenty of the enemy struck, and of the ships which escaped, four were afterwards taken by Sir Richard Strahan. But unhappily the fleet did not anchor, as Lord Nelson with his dying breath had enjoined; a heavy gale came on from the S.W.; some of the prizes went down, some were driven on the shore, one effected its escape into Cadiz, others were destroyed, and four only were, by the greatest exertions, saved. Still, by this mighty achievement, the navies of France and Spain received a blow from which they were not destined soon to recover; the gigantic combinations of Napoleon, with a view to a descent upon England, were completely baffled; and the success of his campaign of Austerlitz was in a great measure neutralized. The remains of Lord Nelson were buried at St Paul's, on the 9th of January 1806. It is needless to add, that all the honours which a grateful country could bestow were heaped on the memory of the man who had achieved this unequalled victory.[1]

Nelson, Robert.

In Lord Nelson's professional character were united all the highest qualities of a great commander,—wonderful foresight, prompt judgment, never-failing presence of mind, ardent zeal, unbounded confidence in the resources of his own mind, and that intuitive decision in the midst of difficulty and peril which is the distinguishing attribute of great military or naval genius. His daring was without rashness, and his enterprise founded upon the most skilful calculation; his ardour never outran his understanding, nor his love of glory a due consideration of the material and moral means by which alone success can be obtained. His talents for command were of the highest order, and he knew the invaluable secret of inspiring other men with confidence in him, as well as with confidence in themselves. But the best character which can be drawn of him is the history of his achievements, all stamped with the impression of his genius; and, that nothing might be wanting to the consummation of his renown, he departed in a bright blaze of glory, leaving to his country a name which is her pride and boast, and an example which will continue to be her shield and her strength. (See, in particular, the *Dispatches and Letters of Vice-Admiral Lord Viscount Nelson*, by Sir Nicholas Harris Nicolas, 7 vols., Lond. 1844–46; also Southey's *Life of Nelson*, in 2 vols. 12mo; Life by Clarke and M'Arthur, 8vo; Ekins' *Naval History*, 4to; and James's *Naval History*, 6 vols. 8vo.) (J. B—E.)

NELSON, *Robert*, the author of several works on practical religion, was the son of a wealthy London merchant, and was born in 1656. After attending St Paul's School, he studied at Cambridge as a fellow-commoner of Trinity College. On his entrance into active life, his worth and accomplishments raised him to a high place in the estimation of the learned. He became the bosom-friend of Tillotson; and in 1680 was elected a fellow of the Royal Society. But not until 1691, at the conclusion of a series of visits to the Continent, did his character as an earnest friend of religion and philanthropy begin to appear in its full excellence. He became a liberal patron of charity-schools; and there was not a scheme for propagating religion, either at home or abroad, to which he did not afford substantial encouragement; while at the same time his pen was perseveringly employed in advocating practical religion. It was while engaged in performing the pious task of writing the life of his old tutor, Bishop Bull, that he contracted his last illness. His death took place in 1715. Nelson's best-known works are,—*A Companion for the Festivals and Fasts of the Church of England*, 8vo, 1704; *The Great Duty of Frequenting the Christian Sacrifice*, 8vo, 1707;

[1] Lord Nelson's brother, the Rev. William Nelson, D.D., was created Earl Nelson of Trafalgar and of Merton on the 20th November 1805, with an annual grant of L.6000, and with permission from his Majesty to inherit his deceased brother's Sicilian dukedom of Bronté. Besides L.100,000 for the purchase of an estate, L.10,000 were voted to each of the hero's sisters. His dying request in behalf of Lady Hamilton and his "adopted daughter Horatia Nelson Thompson," the British nation saw fit to utterly disregard. The one he left, in a codicil to his will, written a few hours before his fall, "a legacy to my king and country;" and the other "to the beneficence of my country." "These," continues the document, "are the only favours I ask of my king and country at this moment, when I am going to fight their battle;" yet it appears from Pettigrew's *Memoirs of Nelson*, vol. ii., that this codicil was virtuously concealed by the hero's reverend brother until the parliamentary grant to himself was duly completed. The subsequent years of the unfortunate Lady Hamilton's life one had rather pass over. She died at Calais in extreme poverty and great distress on the 6th January 1814. Nelson's daughter, Horatia,—respecting whose maternal extraction Sir N. H. Nicolas has diligently collected so much unsatisfactory information (Nelson's *Dispatches*, &c., vol. vii., pp. 369–396), in his attempt to remove the generally received and most obvious opinion on the point,—was married in February 1822 to the Rev. Philip Ward, an English clergyman. Some endeavour has recently been made, it seems, to assist her children in entering upon life, with the design, probably, of atoning in some measure for the neglect shown to the dying request of the hero of Trafalgar.

Nemausus ‖ Nemesianus.

The Practice of True Devotion, 8vo, 1708; and *The Whole Duty of a Christian*, 8vo, 1718. They have all passed through several editions.

NEMAUSUS (the modern *Nîmes*), a city of Gallia Narbonensis, was the capital of the Volcæ Arecomici, and was situated on the road between Italy and Iberia. As early as the reign of Augustus it was a *colonia;* and in the days of Strabo it possessed the *Jus Latii*, and was on that account independent of the Roman governors. The territory of Nemausus comprised twenty-four populous villages. Its most notable product was cheese, which was exported to Rome. There are still remaining many striking monuments of the splendour of the ancient city of Nemausus. The principal of these are a spacious amphitheatre, a temple called the *Maison Carée*, a structure known as the *Tour Magne*, and the famous Roman aqueduct, named the *Pont du Gard*. (See NIMES.)

NEMEAN GAMES, THE, constituted one of the four great national festivals of the Greeks. The ordinary account of their institution is the legend that follows. As Hypsipyle, the nurse of Opheltes or Archemorus, the infant son of Lycurgus and Eurydice, was sauntering one day with her young charge through the valley of Nemea, near the city of Cleonæ, she met the seven champions on their way to attack Thebes. They asked her to conduct them to the nearest fountain, where they might slake their thirst. She left her child lying on the ground, and hastened away to comply with their request. On her return, she found that Opheltes had been devoured by a dragon. The seven champions, after destroying the monster, celebrated funeral games in honour of the child. These games falling into disuse, were revived by Hercules after he had slain the Nemean lion, and were then for the first time consecrated to Jupiter. They derived their name from the grove Nemea, in which they were held. There a temple, a theatre, and a stadium were in course of time erected; and thither, twice every Olympiad, in summer and winter alternately, athletes of every kind, and even musicians, were wont to flock from all parts of Greece. The judges were chosen by turns from Cleonæ, Corinth, and Argos, and, in commemoration of the funereal origin of the festival, they were arrayed in sable garments. A chaplet, formed of olive branches, and afterwards of green parsley, was the reward of the victors. The last time at which the celebration of the Nemean games is mentioned in history is in the reign of Hadrian. They seem to have been finally discontinued shortly afterwards. The ruined temple of Jupiter Nemesius still indicates the scene of this great biennial festival.

NEMESIANUS, MARCUS AURELIUS OLYMPIUS, a Latin bucolic poet, flourished at the court of the Emperor Carus towards the close of the third century, and is supposed, from the epithet "Carthaginiensis" generally attached to his name, to have been a native of Africa. In the poetical contests of that day he owned no superior except the young prince Numerianus. "He shone out," says Vopiscus, "adorned with all the crowns of victory." His bucolic poems were three; and under the several names of *Cynegetica, Halieutica*, and *Nautica*, treated of hunting, fishing, and aquatics. A fragment of the first of these, amounting to 325 hexameter verses, is the only authenticated production of Nemesianus that is extant. It contains instructions for the rearing of dogs and horses, and the forming of nets and other hunting apparatus. The best edition is that of Stern, 8vo, Halle, 1832.

Wernsdorf, in his *Latinæ Poetæ Minores*, argues, on grounds somewhat plausible, that the piece entitled *Laudes Herculis*, usually printed among the works of Claudian, belongs to Nemesianus. Four of the eclogues generally ascribed to T. Calpurnius Siculus are sometimes erroneously attributed to the same author.

Nemesis ‖ Nemours

NEMESIS is generally represented in Grecian mythology as the daughter of Night. The ideas regarding her character seem to have been gradually developed. In the days of Hesiod she was regarded as the impersonation of the upbraiding of conscience, of the natural dread of punishment that springs up in the human heart after a sin has been committed. But as the feeling of remorse may be considered the vengeance of the offended moral law, Nemesis came to be held, especially among the tragic poets, as the goddess of retribution, relentlessly pursuing the guilty until she has driven them into irretrievable woe and ruin. In performing this function, however, she often suddenly cast the minions of fortune from the summits of prosperity down into the lowest depths of misery. By this circumstance a new phase of her character was developed. She came to be regarded as the personification of that supposed divine jealousy that is kindled at the sight of great human felicity, never rests until it has brought a serenely happy life to a gloomy and tragical close, and thus acts as the impartial distributor of happiness and unhappiness among the sons of men. Nemesis had several surnames. She was called *Rhamnusia* or *Rhamnusis*, from Rhamnus, a town of Attica, where she was worshipped; and *Adrasteia*, from Adrastus, King of Argos, who first built a temple to her on the River Asopus (*Asopo*). The ancients generally represented Nemesis as a crowned virgin, majestic in her bearing, and closely resembling Venus in the grace of her person and the beauty of her countenance, with a whip in one hand and a pair of scales in the other.

NEMESIUS, one of the ablest of the ancient Christian philosophers, and the author of a Greek treatise *On the Nature of Man*, flourished, as bishop of Emesa in Syria, probably about the end of the fourth century. His book is the only record that remains of his existence. It seems to be little else than a synopsis of the orthodox philosophy of that day, written in a style generally clear, easy, and elegant. Man is considered as a complex being, composed of a body and a soul. It is while discussing the former of these divisions that Nemesius displays his learning and his power of theorizing to the best advantage. His remarks on the spleen, the nerves, the glands, and other organs of the body, prove him to have been a thorough adept in all the physiological lore of that age; and his curious speculations touching the motion of the pulse, and the use of the bile, have led Fell, Brucker, and others of his indiscriminate admirers, to suppose that he was acquainted with the circulation of the blood and the functions of the liver; an opinion, however, which Freind, in his *History of Physic*, and Haller, in his *Bibliotheca Anatomica*, contest. Treating of the other great division of his subject, Nemesius considers the soul as composed of two parts, the rational part consisting of thought, memory, and especially will, and the irrational part consisting of the desires and the passions. On the liberty of the human will, and other kindred subjects, his views are just and profound. He holds, however, the Platonic doctrine of the pre-existence of the soul.

An edition of the work of Nemesius in the original was given to the world by Nicasius Ellebodius, 8vo, Antwerp, 1565; and by Fell, 8vo, Oxford, 1671. The latest and the best edition is that of F. Matthæi, 8vo, Halle, 1802. It was translated into English by George Wither, 12mo, London, 1636; into German by Osterhammer, 8vo, Salzburg, 1819; and into French by J. B. Thibault, 8vo, Paris, 1844.

NEMOURS, a town of France, department of Seine-et-Marne, on the Loing, nearly surrounded by that river and by the canal which joins the Seine and Loire, 10 miles S. of Fontainebleau. It is well built, and has broad streets. The old castle, formerly the residence of the dukes of Nemours, contains a public library and several other establishments. There is a handsome parish church, an hospital, and a theatre. Leather, beer, vinegar, marble, earthenware,

Nenagh || Neoptolemus.

&c., are manufactured here; and an active trade is carried on in the produce of the country. Pop. 3782.

NENAGH, a town of Ireland, province of Munster, and county of Tipperary, occupies a beautiful situation on a hill near the River Nenagh, 23 miles N.E. of Limerick, and 82 miles W.S.W. of Dublin. It is well built, and contains one principal street, which is crossed at right angles by four others. There is an Episcopal, a Roman Catholic, a Methodist, and an Independent church; several schools; a fever hospital; dispensary; and barracks. Nenagh has also an ancient castle of Norman architecture, and the remains of a Franciscan monastery. Woollen cloth, tobacco, soap, and candles, are manufactured here; and a considerable trade is carried on in corn, cattle, bacon, butter, and eggs. Several fairs are held yearly here. Pop. 9292.

NENE, or NEN, a river of England, Northamptonshire, is formed by two branches, one from the north, rising at Naseby, and the other from the west, rising near Staverton, a village S.W. of Daventry. These streams unite at Northampton, and thence the river flows towards the N.E. through a beautiful valley, and falls into the Wash. The Nene receives many tributaries, though of small size, from the left; but none from the right, as the hills present a steep side to it, and send their streams to the Ouse. Northampton and Peterborough are the principal towns on its course.

NENNIUS, the reputed author of an ancient history of the Britons, entitled *Historia Britonum*, is said to have been abbot of Bangor at the beginning of the seventh century. The book which is ascribed to him commences with a fabulous account of the colonization of the island, and brings the narrative down to the year 655. Its chronological blunders, and the many other proofs of its want of authenticity, render it a very unsafe historical authority. It is chiefly valuable on account of its containing those stories of King Arthur, Merlin, and other legendary heroes, which became such favourite themes among the authors of succeeding ages. The latest editions of the *Historia Britonum* are those by the Rev. W. Gunn, B.D., 8vo, London, 1819; and Mr Joseph Stevenson, 8vo, London, 1838. (Wright's *Biographia Britannica Literaria.*)

NEOPHYTES, a name given by the ancient Christians to those heathens who had newly embraced the faith; such persons being considered as regenerated, or born anew. The term *neophytes* has also been used for new priests, or those just admitted into orders; and sometimes for the novices in monasteries or convents. It is still applied by Roman Catholic missionaries to converts made among the heathen.

NEO-PLATONISTS. See ALEXANDRIAN SCHOOL.

NEOPTOLEMUS, the son of Achilles and Deidameia, daughter of Lycomedes, King of the Dolopians, was born shortly before the Trojan war. When it was prophesied, towards the close of the siege of Troy, that the city could not be taken without the son of Achilles, Ulysses and Diomede were despatched to bring the young man, and found him in the house of his maternal grandfather, in the island of Scyros. He was then called Pyrrhus, on account of his *fair* hair; but after his arrival at the scene of war, he was generally known by the name of Neoptolemus, *i.e.*, "the young warrior." The son of Achilles soon proved himself worthy of his brave, savage, and vindictive father. On the night of the sacking of Troy his deeds were bold and atrocious beyond those of all the other Greeks; and it was his sword that was most fatal to the royal house of Priam. He was among the foremost to leap from the wooden horse upon the devoted and unsuspecting city: he dashed down the little Astyanax, the child of Hector, from the top of a tower; he sacrificed the Princess Polyxena upon the tomb of Achilles; and he slew Priam and Polites, father and son, together, at the altar of Jupiter, before the eyes of Queen Hecuba and her daughters. On the distribution of the captives, Andromache, the widow of Hector, fell to his lot, and became his wife. After this date the various accounts of the life of Neoptolemus are very contradictory. According to some authors, he returned to his hereditary kingdom of Phthia; while, according to others, he fixed his abode permanently at Epirus. It is generally agreed, however, that Menelaus and Helen bestowed upon him the hand of their daughter Hermione. Shortly after this he was slain, during a visit to Delphi, by some vindictive foe, about whom ancient writers are not agreed. His remains were interred within the temple; and long afterwards, when the Gauls attacked the city, his spirit rose, it is said, to defend the sacred place.

Neots, St || Nepaul.

NEOTS, ST, a market-town of England, Huntingdonshire, stands on the right bank of the Ouse, 9 miles S.W. of Huntingdon, and 56 N. by W. of London. It has several well built streets, and a market-place; but from the lowness of its situation, the town is exposed to the danger of being flooded by the river. The church of St Neot's, which is considered the finest in the county, is in the perpendicular English style, and has a handsome tower 150 feet high. There are other churches in the town, belonging to the Baptists and Methodists, and several schools. The Ouse is here crossed by a bridge of eleven arches, six of which are on the low ground near the river. The principal manufacture in St Neot's is paper, which gives employment to many of the inhabitants. A large retail trade is carried on. Pop. (1851) 2951.

NEPAUL, or NIPAL, an extensive country of Hindustan, long and narrow in its form, and, although somewhat curtailed in its dimensions by the progress of British conquest, still one of the largest and most compact independent kingdoms in the country. To the N. it is bounded by the great mountain-wall of the Himalayas, which separates it from Thibet; to the S. the Nepaul territory reaches about 20 miles beyond the base of the mountains into the plains, being bounded by the provinces of Purneah, Tirhoot, Sarun, and Goruckpore; to the E. by the British territory of Darjeeling and the native principality of Sikkim, which extends to the Chinese frontier. The kingdom of Oude, the territories of which have been recently annexed to the British dominions, forms the boundary on the S.W. Previously to the war with Britain in 1814-16, the conquests of the Ghoorkhas or Nepaulese extended to the banks of the Sutlege, the eastern river of the Punjab; but the boundary is now the River Cali, or the western branch of the Goggra, which separates the Ghoorkha territory from the British province of Kumaon. The above limits, however, include a territory much larger than that to which the peculiar name of Nepaul proper belongs, and made up of conquests gained by the Ghoorkhas within the last eighty years from a variety of petty hill states. This extended dominion is mostly included between the twenty-seventh and thirty-first degrees of N. latitude, and in extreme length may be estimated at 460 miles, by 150 miles in breadth. The following are the modern districts into which this territory is divided:—

1. Nepaul proper.
2. Country of the 24 rajahs.
3. Country of the 22 rajahs.
4. Muckwanpoor.
5. Kirauts.
6. Khatang.
7. Chayenpoor.
8. Saptari.
9. Morung.

Aspect of the country.

Nepaul is extremely diversified in its surface. Among its lofty summits is Mount Everest, the highest peak in the world (29,002 feet), while the whole range which forms its northern boundary rises to the level of perpetual snow. These high mountains generally decline into lower hills, from which they are separated by fine valleys, still considerably above the level of the plains, and the lowest belt of the Nepaul dominions forms part of the great plain of Hindustan. Immediately to the N. of this flat country there is a region of nearly the same width, consisting of small hills, which rise gra-

Nepaul. dually towards the north, and are watered by many streams from the loftier mountains to which these hills gradually unite. The hills are covered with forests: on the lower hills are found the saul forests, which, with the pines, are not surpassed in any country, either for straightness or size, as well as for strength and durability. Higher up there is a variety of other trees, and amongst the northern hills many pines, and an abundance of mimosa, from which the catechu of India is obtained; also oaks, walnut and chestnut trees, hornbeam, Weymouth pine, and common spruce, for the most part of but very little value, owing to the inaccessible nature of the country. The breadth of this mountainous belt immediately north and east of Catmandoo is estimated at from thirty to forty miles. This is a very elevated region, consisting of one mountain heaped upon another rising to a great height, so that in winter their summits are for a short time covered with snow, and it even falls sometimes in the valley below. A hoar frost also very often covers the ground; but although the cold is occasionally for three or four months severe enough to freeze the tanks and pools of standing water, the rivers are never frozen. Between the mountains are narrow valleys of from 3000 to 6000 feet above the plains of Bengal. The height of the valley of Nepaul, measured by the barometer, is about 4000 feet. It is nearly of an oval figure; its greatest extent from north to south is twelve miles, and it stretches east and west nine miles; and though it scarcely lies in a higher latitude than twenty-seven and a half degrees, yet it enjoys nearly the same climate as the southern countries of Europe.

Climate. Lying near a region buried in snow, its climate must no doubt be somewhat modified by such a vicinity. Still Kirkpatrick mentions, that in summer the thermometer rose once to eighty-seven degrees during his residence in the valley; and its usual height about noon varied from eighty-one to eighty-four degrees. At sun-rise it was commonly between fifty and fifty-four, and at nine in the evening it generally fluctuated from sixty-two to sixty-six degrees. Fifty-one observations, from the 17th to the 25th March, gave an average of sixty-seven degrees. The seasons are nearly the same with those in Upper Hindustan. The rains commence a little earlier, and set in from the south-east quarter; they continue for days without intermission, and are generally very violent. The mountain-torrents rush down in consequence with great impetuosity, overflowing their banks, and spreading over all the adjacent country. By these violent inundations, the plain is cut into numerous and deep ravines. The temperature varies necessarily with the elevation of the ground; so that by ascending the adjacent mountains, the heat of Bengal may in the course of a few days be exchanged for the cold of Russia.

Produce. The produce also varies along with the climate. In some parts rattans and bamboos, both of enormous dimensions, are seen, and others produce only oaks and pines. In several parts the pine-apple and sugar-cane ripen, whilst others yield only barley, millet, and similar grains. The mulberry grows luxuriantly all over the hills; and they cut its young and tender shoots annually, whilst full of leaves, and, having dried them, stack them for fodder, which is said to be both nutritious and agreeable to the animals. In this comparatively cold and elevated climate, the periodical rains are not favourable for the ripening of fruits, which everywhere abound, but never come to perfection, the heat of the climate not being sufficient to bring them to maturity before the approach of the rains. Peaches grow wild on every hill; but one side of them is rotted by the damp, whilst the other side is green; and the grapes, which grow without shelter from the rains, are always bad. Kirkpatrick, however, from the spontaneous productions which he saw on the spot, namely, the peach, the raspberry, the walnut, the mulberry, and others, thought that all the fruits and esculent vegetables of England might with proper attention be successfully raised in the mountainous valleys of Nepaul. In the warmer valleys, the pine-apple is uncommonly fine; as also the orange, which ripens in winter. The abundant rains, if they spoil the fruits, are, however, very favourable to the produce of grain; and wherever the land can be levelled into terraces, however narrow, it is well adapted for transplanted rice, which ripens after the rains have ceased. The least rocky faces of the hills are generally cut into these terraces, which are seen everywhere rising above each other. This operation produces numerous strips of level ground, more or less narrow, according to the steepness of the hills. Great labour and care are bestowed upon this operation, and it is often necessary to build a retaining wall to support the edge of the small strip of ground. Much attention is also paid to the levelling of its surface, to fit it for irrigation, as every rivulet is first conducted by drains to the higher cultivated spots, and then, after saturating them, to the lower range of fields. In some parts the same land gives a winter crop of wheat and barley. Where the land is too steep for terraces, it is generally cultivated after fallow with the hoe, and produces rice sown broadcast, maize, cotton, three kinds of pulse, a kind of mustard, manjeet or Indian madder, wheat, barley, and sugar-cane. Tobacco is an article of general cultivation in these hills, and it is considered as of a fine quality. It is exported in considerable quantities both to the plains and to Bootan. One of the great staples of agriculture in these mountainous countries is a large species of cardamom; and ginger is likewise a valuable production in the country between Nepaul Proper and the Cali, though rice is still the main dependence of the farmer. Various dry rices are cultivated in Nepaul, under the general name of ghya, some of which, so far from needing hot weather to bring them to maturity, are actually raised in situations very much exposed to falls of snow; whilst others do not require, as in Bengal, to be flooded, but flourish in the driest and loftiest spots. There are also amongst the spontaneous productions of this fertile soil several edible roots and herbs, which form a considerable part of the sustenance of the poorer inhabitants. Of these there are a species of yam, and a kind of wild asparagus, as well as various other plants well deserving the attention of travellers. There are also medicinal plants, and a rich variety of dyeing drugs procured from bitter or aromatic woods, which grow naturally in the country, and which are held in great estimation. The jeea is a very curious plant, from the expressed leaves of which is produced a juice called cherris, which is a potent narcotic, and possesses very valuable qualities, burning with a flame as bright as that of the purest resin. Its leaves are fabricated into a species of hemp, from which the Newars manufacture some coarse linen, and likewise a very strong kind of sackcloth. Though the soil seems well adapted to the growth of kitchen vegetables, yet the inhabitants are either too indolent or too unskilful to raise them. The only kitchen vegetables which Colonel Kirkpatrick met with were cabbages and pease of the worst kind. They have the Thibet turnip, but cannot raise it, any more than the potato, without renewing the seed annually. Amongst these mountains are found the common nettle and a plant resembling wormwood; also a curious shrub called khaksi, the leaf of which answers the purpose of emery or sand-paper, giving a fine polish to the harder woods.

Animals. The mountain pasture, though not so good as that in the low country, yet supports numerous flocks of sheep, which migrate with the seasons, in winter to the lower valleys, and in summer to the alpine regions, where they feed upon the herbage of those extensive tracts which lie in the neighbourhood of perpetual snow. The sheep in these altitudes are of considerable size, and have fine wool; the larger are the same as in the lower countries, but are not numerous.

Nepaul. Buffaloes are not reared by the natives, neither are hogs nor goats, though the country is admirably adapted for both. Horses are brought from Thibet and from Kattywar, Sinde, and Guzerat; also the large ox of Thibet, or the *Bos grunniens*, described by Turner, the beautiful tail of which forms one of the exports from Nepaul; and the goat which produces the shawl wool. The kustoora or musk-deer is a native of Lower Thibet, though it is not very abundant anywhere. It is usually caught by means of a snare made of a particular kind of mountain bamboo. It is difficult to obtain the musk pure, even at Catmandoo; and Colonel Kirkpatrick mentions, that it is even usual to adulterate it whilst it is yet in the bag on the body of the animal. In the great forest which skirts the Nepaul territories throughout their whole extent, from Serinagur to the Teesta, wild animals abound. Elephants are found here in great numbers, and are a source of revenue to the Nepaul government. About 200 or 300 of these animals are caught annually; but most of them being very young, and not being above seven feet and a half in height, they are not of great value. They are extremely mischievous, and two or three of them sometimes take possession of the road, and obstruct the progress of travellers for a considerable time. A large herd of them assaulted the camp of the Nepaul deputies when they were on their way to Patna, and were with great difficulty driven away. They sometimes issue from the forest in droves, and overrun the cultivated country on its borders, penetrating sometimes a considerable space within the company's territories. The rhinoceros, the tiger, the leopard, and other ferocious animals, find shelter in the depths of the forests. The animal known in Bengal by the name of the Nepaul dog is brought from Upper and Lower Thibet, of which it is a native. It is a fierce, surly creature, about the size of an English bull-dog, and covered with thick long hair. Several very fine birds are found in these mountainous countries, as the manal (*Meleagris satyra*), and the damphya (*Phasianus impeyanus*). They are a species of pheasants, the damphya being of the golden, and the manal or moonal of the spotted sort. They are both extremely beautiful birds. The chakoor is well known to the Europeans of India under the name of the fire-eater. It is a species of partridge, and derives its name from its reputed power of swallowing fire. The fact is, that in the breeding season this bird is remarkably fond of red pepper, after eating two or three capsules of which, it will bite at a red coal if presented to it. The khaledge is met with in the thickets which overrun the gorges of the mountains near Noakote. The sarus, wild goose, wild duck, and several others of the feathered species common to Bengal and the rest of the countries to the southward of Nepaul, are occasionally seen in this and the adjacent valleys; where, however, they merely appear as birds of passage, making Nepaul only a stage in their flight from Hindustan to Thibet.

Minerals. The stones and ores collected in the country indicate the existence of a variety of minerals in the mountains of Nepaul, such as iron, lead, copper, &c. It was formerly a prevalent idea amongst the Hindus, from whom it was received by the British, that the country contained mines of gold. The only foundation for this notion appears to be, that in the course of commerce the gold of Thibet passed into Bengal and Bahar through Nepaul; or that a few grains of gold were occasionally collected in the sands of the rivers, or found in the consecrated pebbles of Gunduck; or sometimes that specimens of gold ore have been sent to the governor-general by way of presents or curiosities. Other accounts of gold mines may also be referred to the circumstance of scanty particles of gold being found in the beds of torrents from the mountains. With regard to silver, it is said that some veins of it have been discovered to the westward of Noakote. But Kirkpatrick, in his account of Nepaul, suspects that it has no better foundation than that silver has lately been found in certain ores which were very rich in lead; whilst others appeared to be a species of galena, well worth the working for the sake of the silver which they contained. Several attempts had been made to extract the silver, but by such an unskilful process, that most part of the baser metal was sacrificed, in consequence of which the return scarcely repaid the expense. The copper is found quite near the surface of the earth, the ore being dug from trenches open above, so that the work is entirely interrupted by the rainy season. Those ores are found in several varieties, and are said to be rich and of an excellent kind. The mine is shared amongst certain families along with the rajah, who, there is every reason to believe, claims the lion's share, and, as in all other parts of Hindustan, leaves the workmen a bare subsistence. Oude was formerly supplied with copper from Nepaul; but of late years it has been superseded by European copper, owing to the difficulties and expense of transferring it to the market through a mountainous country without navigable rivers. The iron ore is also found near the surface, and is not surpassed in excellence by that of any other country. Sulphur is likewise abundant, and procured in great quantities. There is no good authority for believing that either the ores of antimony or mercury are found in the territories of Nepaul; but the western parts abound in arsenic and pyrites, though these sulphureous ores are no longer worked, on account of the deleterious effects occasioned by the operation. Stone is found in abundance and variety, particularly jasper and marble; but the houses are universally built of brick, because the use of stone, though abounding everywhere, is prevented by the expense of carriage in a country where the roads do not admit of wheel-carriages, and where there is no navigation. There is said to be a considerable mass of rock crystal near Ghoorkha, and limestone as well as slate abounds everywhere; yet there are no limekilns in the country, the only cement employed being mud, which, the natives pretend, answers better in their humid climate than mortar.

Nepaul.

Moun-tains. The alpine region belonging to Nepaul is about the same breadth of thirty or forty miles from north to south. Scattered peaks are here seen covered with perpetual snow, until, in advancing to the boundaries of Thibet, everlasting winter reigns. This inhospitable region consists chiefly of immense rocks rising into sharp peaks and tremendous precipices, covered with snow, and almost constantly involved in clouds. Some of these mountains are estimated to rise 25,000 feet above the valley of Nepaul. The rains here are periodical, as in the plains of Hindustan, and fall in the hottest season of the year. The snowy ridge of the Himalaya Mountains, though it has a winding course, has few interruptions, and is in most places impassable. Several rivers which take their rise in Thibet make their way through the mountainous ridges, but by such narrow chasms, and amidst such enormous precipices, that these openings afford no practicable communication between the mountains and the plains. In the mountain passes no sort of baggage or merchandise is transportable, except on the shoulders of hill porters. The price of this carriage is regulated by the government.

Popula-tion. The numerous valleys which are interspersed throughout the mountains of Nepaul are inhabited by a variety of mixed races. The aboriginal inhabitants appear, from their physiognomy, to have been of Tartar or of Chinese origin, and to have had no resemblance to the Hindus either in features, religion, or manners. Before their arrival they had no idea of caste. The period when these mountainous regions were first invaded by the Hindus is uncertain; but, according to the most authentic traditions, it is supposed to have taken place about the fourteenth century. The Hindus who now inhabit these mountains were about this

Nepaul. period driven from their country by the invasion of the Mahommedan sovereign of Delhi, who made proposals to marry a daughter of the rajah of Chitore, celebrated for her beauty. This offer was refused, and the consequence was that his city was captured and destroyed; and, to avoid the hated yoke of the conqueror, great numbers of the inhabitants fled to the mountains. Many of the chiefs amongst the mountain tribes, accordingly, claim descent from these Chitore princes, although on doubtful grounds. There are a few rajpoots whose claims to a pure descent from the Chitore family are allowed; and the families of the mountain chiefs who have adopted the Hindu rules of purity, and some even who have neglected this, are now admitted to be rajpoots; whilst, on the other hand, the purity of the Chitore blood has been so often contaminated by alliances with the Tartar and Chinese races, that several of the Chitore family have acquired the Tartar countenance, and some of the mountain tribes, by intermarriages with pure rajpoots in a low station, have acquired the oval faces and high noses of that remarkable race. The original purity of the rajpoot blood having been thus lost by indiscriminate alliances, all the hill chiefs, whether their descent from the Chitore family be real or pretended, are now called rajpoots, and hold the principal offices, civil and military, of the petty states into which the country was subdivided before Nepaul was subdued by the reigning family of the Ghoorkhas. In the eastern parts of the country the aboriginal tribes still remain; and, until the predominance of the Ghoorkhas, they enjoyed unmolested their customs and religion. But west of the Cali the case is different, almost all the inhabitants claiming a descent from the Hindu colony. They accordingly consist principally of the two superior classes of Hindus, or brahmins and chetrees, with their various subdivisions.

East of the Cali the tribes which possessed the country were chiefly, 1. Magars, who occupied the lower hills in the western parts, and were very soon converted to the brahmin doctrine of abstaining from beef. They are at present enlisted by the Ghoorkha sovereigns, and compose a great majority of their troops. 2. The Gurungs, a pastoral tribe, shift their abode between the mountains and the valleys with the summer and the winter. They still adhere to the lama priesthood and the Buddhist religion. They cultivate with the hoe, are diligent miners and traders, and employ the numerous flocks which they possess in conveying their goods to market. 3. The Jariyas form a numerous tribe, and inhabit the lower hilly region between the Cali and the Nepaul valley, and are now nearly all converted to the brahminical doctrines. 4. The Newars are an industrious people, following agriculture and commerce, and are more advanced in the mechanical arts than the mountain tribes. The greater part of them adhere to the tenets of the Buddhists: though they have adopted the distinctions of caste, they do not acknowledge the lamas, and have a priesthood of their own. The more fertile part of what is called Nepaul Proper was chiefly occupied by the Newars, a race addicted to agriculture and commerce, and far more advanced in the arts than any other of the mountain tribes. Their style of building, and most of their arts, appear to have been introduced from Thibet. All the Newars burn their dead; they eat buffaloes, sheep, goats, fowls, and ducks, and are addicted to the immoderate use of spirituous liquors. They live in towns or villages, in houses built of brick cemented with clay, and covered with tiles; these houses are three stories high, the ground-floor being allotted to the cattle and poultry, the second to the servants, and the third to the family of the owner. Their rooms are low, and have a mean and dirty appearance, and, besides, are infested with vermin, which, in addition to the filth, the offals of the shambles, and the blood of their sacrifices collected in the streets, give their towns an exceedingly offensive aspect to Europeans. The Newar women are never confined to the house. At the early age of eight years they are carried to a temple, and married, with the usual ceremonies of the Hindus, to a fruit called *ull*; and when they arrive at puberty they are betrothed to a man of the same caste, and the parents give a dower to the husband, or rather her paramour, their manners being extremely licentious. Like the women amongst the Nairs, they may in fact have as many husbands as they choose, being at liberty to divorce them as often as they please, and upon the slightest pretences. The Newars are peaceable, industrious, and even ingenious; much attached to the superstition which they profess, and now reconciled to the chains imposed on them by their Ghoorkha conquerors. Their occupations are chiefly those of agriculture; and they are, besides, almost exclusively employed in the arts and manufactures of the country. They are generally of the middle size, possessed of great corporeal strength, with broad shoulders and chest, very stout limbs, round and rather flat faces, small eyes, low and somewhat spreading noses, and open and cheerful countenances, with little or no resemblance, according to Kirkpatrick, to the Chinese countenance. The complexion of the women is somewhat between a sallow and a copper colour. 5. The Dhenwars and Mhanjees are the husbandmen and fishers of the western districts. 6. The Bhootias. Though some families of this race are planted in the lower lands, they occupy, generally speaking, such parts of the mountainous country as are included in the Nepaul territories. They shave their heads, and observe many idolatrous rites and customs. 7. The Bhanras are a sort of separatists from the Newars, and are supposed to amount to 5000. They observe many of the customs of the Bhootias. To the eastward some districts of the Nepaul dominions are inhabited by tribes, such as the Limbooas, Nuggerkootees, and others, of whom little more is known than the names. Nepaul.

With regard to the number of inhabitants within the bounds of Nepaul, we have no data to form any thing like an accurate estimate. The wild and rugged nature of the country gives no ground to suppose that the population is considerable. It is in the valleys that the population is collected; and these, says Kirkpatrick, with the exception of Nepaul and two or three others, are little better than mountainous cavities. Even the Terriani, or low belt of land which runs along the southern frontier, is but indifferently peopled, the villages being, according to the traveller already mentioned, very thinly scattered, and mean both in their appearance and in their size. The Nepaulese themselves give the most exaggerated account of their numbers. They reckon their population by houses; and to Patan, their largest town, they assign 24,000 houses, to Bhatgong 22,000, and to Catmandoo 18,000. This would give a population of 640,000. There are, besides, many large villages and towns scattered around Kirteepoor, containing 12,000 houses; Theamee, Buneba, Pharping, Punonlee, Dhulkill, Chappagang, all containing from 6000 to 7000 houses; and, besides these, there are reckoned between twenty and thirty smaller, of from 1000 to 4000 houses, all within the valley of Nepaul. But this gives a population that sets probability at defiance, and is considered, both by Frazer and Kirkpatrick, as a glaring fallacy. According to the latest accounts, the population of Nepaul is estimated at nearly two millions.

The lands are held by various tenures. Those constituting crown-lands, or the rajah's immediate estates, are chiefly situated in the Ghoorkha territory, though there is hardly any portion of the Ghoorkha conquests in which the prince has not appropriated land to his own use. Some of these lands are cultivated by husbandmen, who receive a share of the produce; others are tilled by the neighbouring husbandmen, who are obliged to dedicate a certain State of property.

Nepaul. number of days in the year to this service. From such lands the rajah draws all the supplies necessary for the support of his household. The brahmins also possess lands, the title to which they receive by royal investiture. These lands are rent free, saleable, and hereditary; but they may nevertheless be alienated for certain crimes. Their proprietors are bound to the reigning prince for nothing beyond their prayers, though they sometimes consider it as prudent to conciliate him by more substantial gifts. Another tenure by which land is possessed by the Newars, is the payment of a considerable fine when the original titles are confirmed, which must be renewed on the accession of each prince. Other lands pay a rent to the crown, or to the jaghiredar (proprietor), in proportion to their produce. The khyra and barilands are those which are destitute of springs or running water, and which, requiring considerable labour, yield, after all, no very profitable return. These pay a rent according to their produce, which is estimated by the number of spades or ploughs employed. Widows may cultivate as much of this land as they can, without paying any rent at all. The kaith or plantation-lands, which are well supplied with water, and, being situated in the valleys, are fruitful, and yield all the superior kinds of grain, pay the half of their produce to the cultivator, who in return defrays all the charges of tillage, with the exception of the seed. These lands are reckoned to yield from twenty to thirty fold; and they pay different rates to the proprietor, according to the value of their produce.

Military force. The whole population of Nepaul are liable to military service in times of public danger, though they are not regularly trained to arms. But there is a standing army dispersed over the country, besides a large force always in the capital, amounting to 30,000 or 35,000 troops. These troops are regularly trained, disciplined, and officered after the manner of European troops; and they likewise affect the European exercise, dress, and arms. The regular force of Nepaul has so long been accustomed to active service and to constant victory, that they have acquired all the qualities of veteran soldiers, a fearlessness of danger, and a contempt of any foe opposed to them. "They have," says Frazer, "much of the true and high spirit of a soldier, that setting of life at nought in comparison of the performance of duty, and that high sense of honour which forms his most attractive ornament, and raises his character to the highest." These qualities were frequently displayed in the course of the campaign with the British, against whose overwhelming attacks fortresses were defended with a determined bravery, and a patient endurance of famine and misery, that were truly exemplary. And when they at length surrendered a fort which was no longer tenable, they deplored their hard fate, called themselves wretched men that ought rather to have died, and refused to return to their native country; whilst the courtesy they showed to the British, and the reciprocal good offices received and returned, resembled more the generous spirit of European warfare, than the cruel practices of the East. The expenses of the military establishment are mostly defrayed by assignments of land, though in some instances the soldier receives his pay from the treasury, and occasionally from the public granary; others are paid partly in money, and partly in land; but the most usual mode, and the one most agreeable to the troops, is by putting them in possession of tracts of land, on which they generally settle their families, whom they can maintain better in this manner than by any pecuniary stipend. There seems no fixed rate of reward for different ranks, a good deal depending on the interest of the parties, and other incidental circumstances. One of the captains of the rajah's company of guards informed Colonel Kirkpatrick, that the lands which he held yielded him 180 rupees a year, and that he received an additional sum in money of 280 rupees; but added, that he was better off when he belonged to a private company. It may be added, that government evinces great consideration for its military and public servants, being particularly indulgent to their widows, orphans, and other destitute branches of their families. The soldiers are in general stout, thick, and well-built men. They are very brave, and prefer close fighting, giving an onset with a loud shout. During the war with the British they attacked with great valour and impetuosity, advancing to the very muzzles of the cannon. They understand the use of the sabre; and each man wears, besides, a "cookree," or long crooked heavy knife, which may be used in war, but is also of great use in all common operations where a knife or hatchet is required. The soldiers also carry a long sort of matchlocks or muskets. The officers, besides the sword and shield and "cookree," carry bows and arrows, which they use very dexterously. The sword which they use has the edge curved inwards like a reaping hook, but far more straight, and very heavy, particularly at the point, where it is very broad, and ends abruptly square. A few small guns are used; but they are confined to the walls of forts, and never carried into the field. Nepaul.

Govern-ment. The government of Nepaul is essentially a despotism, and is good or bad according to the character or temporary views of the reigning prince. It is no doubt slightly ameliorated by the authority of immemorial customs, and the influence of religion, which no prince, however despotic, can safely disregard; as well as by the occasional opposition of the aristocracy or chiefs. But the great body of the people derive little benefit from the struggle for power between the prince and his nobles. They seem to possess no civil rights, and are at the mercy of their rulers for whatever treatment the latter think proper to give them. It was observed by Kirkpatrick, in the course of his journey into the country, that the carriers were pressed, without ceremony, into the service of government, and compelled to work without any promise of pay; and in the war with the British, a detachment of troops, because they yielded a post to the enemy which they could no longer hold, were punished with extraordinary cruelty, being mutilated in their faces in the most shocking manner. In Europe the progress of improvement has modified the rigour of the most absolute governments; but in Nepaul, as in all the Asiatic states, despotism grows up to the most frightful maturity in the congenial soil of ignorance; and although the arbitrary will of the prince may be opposed by the force of circumstances, yet there is no permanent security for life and property, such as is derived from the authority of fixed laws. The administration of public affairs is carried on by various officers. The first of these is the choutra or prime minister to the rajah, to whom he is invariably akin. His business is to receive and examine all written and verbal communications regarding public business, and to act as a sort of comptroller-general over the inferior departments of administration. He holds his office during the pleasure of the prince, to whom he submits all his reports on matters of state; and the former, if he see proper, refers them for further investigation to a court of inspection appointed for the purpose. He is paid by a commission or fine on every rice plantation, with the exception of those of the Thurgars or nobles and the military. Secondly, the kajees are four commissaries who superintend all civil and military affairs, and are employed in the collection of the revenue, and in the management of the Jaghire lands. They are paid by a tax of one rupee on all taxable lands. Thirdly, the sirdars command the armies of the state, and likewise participate in the management of civil business. Fourthly, the kurdars act as secretaries, preparing all communications from the rajah to foreign powers, or to the officers of state. Fifthly, the kupperdar and the kuzanchee have the charge, the one of the

Nepaul. rajah's private wardrobe, jewels, and kitchen; and the other of the public wardrobe, from which honorary dresses are issued. All these officers are paid by a moderate duty upon all taxable lands. Sixthly, the ticksali or superintendent of the mint is paid by a commission on the import duties from Thibet, and on a tax payable by all natives of Nepaul who return to their country from Lehassa, Diggercheh, or other parts of Thibet. This tax is exacted with a good deal of rigour. Seventhly, the dhurmaudhikar is the chief criminal judge, who commissions all the inferior judges, excepting those who officiate in the farmed districts. The fees in this department are very great; and as most crimes are punishable by fine, the penalties constitute a large source of emolument, which does not by any means favour the pure administration of justice. Civil questions regarding property are decided by another tribunal, the members of which are usually brahmins. Over this court the criminal judge sometimes presides. Intricate questions are occasionally referred to a superstitious ordeal, in which chance decides; and this barbarous process is a sure index to the manners of the people, and to the low state of their civil institutions. There is, besides, a superintendent of the police, a minister who is employed in complimentary embassies to foreign powers, or in carrying orders to public officers. The soubahs are governors of districts, or farmers, and government collectors, acting as officers of revenue, of justice, and of police; and the omrahs are commanders of military posts.

Revenue. The public revenue is derived from land-rents, customs, fines of various sorts, and from mines. Annual presents are made by the soubahs, and by every one who approaches the court; and a sort of arbitrary income-tax is besides levied from all ranks, even the sacred order, who possess free lands, not being exempted. An officer is often employed for the express purpose of collecting this tax, which is rated according to the exigencies of the state, and which mounts up in many districts to more than the regular revenue. According to Colonel Kirkpatrick, who visited the country in 1792, and who derived his information from good authority, the revenue actually remitted to Catmandoo never exceeded thirty lacs of rupees (L.300,000), but it sometimes fell to twenty-five lacs. The subsequent conquests by the Ghoorkha sovereigns were not productive of a great increase of income; and the reduction of territory by the last war would of course occasion a corresponding diminution. The export duties, and the profits on the sale of elephants, bring in from three to four lacs of revenue. The import duties levied on the trade from Thibet, included under the mint, as the returns consist chiefly in silver bullion, amount to about seven or eight lacs. The duties on salt, the profits on saltpetre, which appears to be a monopoly, on copper and iron mines, and the produce of the land-tax, may be estimated at from fifteen to eighteen lacs. Formerly the inhabitants of Thibet were supplied with a silver currency from the mint of Nepaul, on which the treasury gained a profit of a lac of rupees.

Trade. The trade of Nepaul is by no means so extensive as it might be if it were conducted under proper regulations; being shackled by monopolies for the benefit of government, or of a few favoured merchants, who labour to preserve their privileges by the most invidious and corrupt means in their power, and by other injudicious restraints. But, at the same time, the surplus produce of so poor a country could scarcely afford the basis of an extensive trade; and it was accordingly rather the medium of communication between other countries, than remarkable for the extent of its own commerce. Formerly merchants from Cashmere carried their manufactures to Kutti and other towns in Thibet, and received in return the wool produced in these countries from the shawl goat. Such portions of these manufactures as are not used in Thibet were exported by the way of Teshoo Loomboo and Lassa, Nepaul. to Siling or Sining on the frontiers of China, and partly sent to Catmandoo by way of Patna. The principal goods imported in return to answer the demand of Cashmere and Nepaul were teas and silks; and from Patna, it is said, they exported otters' skins to a great amount, procured from the neighbourhood of Dacca. The articles imported into Nepaul from Thibet are coarse woollen cloths, paper, horses, sheep, shawl goats, chowry bullocks, chowries or cow-tails, musk-deer, dogs, falcons, pheasants, salt, sal-ammoniac, hurtal or yellow arsenic, borax, quicksilver from China, gold in grains and in small lumps, antimony, rugs or coarse blankets, munjheet or Indian madder, cherris or extract of hemp, besides various medicinal drugs and preserved fruits, such as almonds, walnuts, raisins, dates. Of these articles, the greater part of the musk, chowries, hurtal, borax, and bullion still find their way to Patna; whence in return are sent north, buffaloes, goats, broad cloth, cutlery, glass ware, and other European commodities, Indian cotton manufactures, mother of pearl, pearls, coral, beads, spices, pepper, betel nut and leaf, camphor, tobacco, tin, lead, zinc, and phajoo, the red powder thrown by the Hindus during the hooly. Besides these articles, utensils in wrought copper, brass, bell-metal, and iron, are sold to the merchants of Thibet. The borax and salt are said to be brought from a lake which is situated nearly north from Catmandoo, about fifteen days' journey beyond the Brahmaputra. The carriers of these articles are a large kind of sheep, with four horns, which appear to be the common beasts of burden in all countries towards the sources of the Indus, Ganges, and Brahmaputra. Formerly the lamas of Lassa and Teshoo Loomboo sent a large sum in bullion to be coined at the mint of Catmandoo, on which an allowance of four per cent. was made for the coinage. But the rapacity of the rajah induced him to alloy the rupee to the amount of eight per cent., which had the effect of putting an entire stop to this source of revenue.

Manufactures. The Newars are almost the only artisans in Nepaul; and they appear to be acquainted with and to exercise most of the handicraft occupations of their neighbours. The Newar women of all ranks, as well as the men, of the hill-tribe of Mugar, weave two sorts of cotton cloth, partly for home use and partly for exportation. These cloths are the dresses of the middling and lower classes, although woollens would be much better fitted for the cold climate of a Nepaul winter. Those, accordingly, who are not very poor, wear woollen blankets, which are manufactured by the Bhooteas, who wear nothing else. The dress of the higher ranks is not manufactured at home, but is imported, consisting of Chinese silks, shawls, low country muslins, and calicoes. European broad cloth is worn by the military alone. They work very well in iron, copper, brass, &c.; and in Lalita, Patan, and Bhatgong, there are considerable manufactories of these articles, and also of a species of bell-metal. One bell which was manufactured at that place measured five feet in diameter. The Thibet bells are superior to those of Nepaul, though a great many bell-metal vessels are made by the Newars, and exported to Thibet, along with those of brass and copper. They are likewise particularly ingenious in carpentry; but it is remarkable that they never use a saw, dividing their wood, of whatever size, by a chisel and mallet. They are skilful in gilding; and they manufacture at Bhatgong, from the bark of a shrub, a very strong paper, remarkably well suited for packages. They distil spirits from rice and other grains, and also prepare a fermented liquor from wheat, munooa, rice, &c. which they call jhaur. It is made somewhat in the manner of malt liquors, but is more intoxicating. The Newar peasants use it in the same manner, and consider it as necessary for their comfort as the labouring people of Britain do porter.

Nepaul. History.

The early history of Nepaul, like that of most of the eastern countries, is buried under a mass of fable. The inhabitants exhibit a list of princes for several thousand years back, which is given in Colonel Kirkpatrick's work, but without any evidence of their authenticity. It is doubtful whether such persons ever existed. We know, however, that Nepaul was the scene of important revolutions, though it never was subjected to the Delhi emperors, or to any of the other great Asiatic powers. It is said to have been completely subdued in A. D. 1323, by Hurr Singh, one of the princes of Oude, who was driven out of his own possessions by the Patans. But from that period there exists no accurate information respecting the dynasties which ruled during the interval, or the race of princes who governed Nepaul at the time of the Ghoorkha conquest. Runjeet Mull was the last of the Surya Bansi race, or children of the sun, that reigned in Nepaul. He formed an alliance with Purthi Nirain, which ended in the loss of his dominions, of which he was stript by his ally in the Newar year 890 or 888, corresponding to A. D. 1768. He possessed great courage and insatiable ambition, and was indebted for his success in war to his introduction of firelocks and European discipline amongst his troops. It was in his reign that Captain Kinloch, with a British force, endeavoured to penetrate into Nepaul. But, from the sickness of the troops, and the difficulty of the country, the enterprise was abandoned. Purthi Nirain died about three years after the final conquest of Nepaul, that is, in the year 1771. He left two sons, Singh Pertaub and Behadur Shah, the former of whom succeeded to the throne, and, conceiving a jealousy of his brother, threw him into prison, whence he was with difficulty released by the interference of one of the spiritual guides of the Ghoorkha family, on condition that he should live in exile. Singh Pertaub, after having extended his father's conquests, died in 1775, leaving one son, who was an infant. Behadur Shah, on the death of his brother, returned from his exile to Catmandoo, and, having placed his nephew on the throne, assumed the office of regent. But the mother of the infant prince, Rajender Letchemi, contrived to supplant Behadur Shah in his office, and even to secure the person of her rival. Through the mediation, however, of one of the priests, an accommodation took place, and Behadur Shah was thus enabled to seize and confine the ranee in his turn. Neglecting, however, to conciliate the chief men of the state, he was again driven into banishment, from which he did not return till the death of the princess, when he re-assumed the regency without opposition. In the course of his administration, Palpa, and many other petty states to the westward, Bhote to the north, and Sikkim to the east, were compelled to submit to the rule of the Ghoorkhas.

Towards the close of the administration of Mr Hastings in India the Ghoorkha sovereigns were involved in hostilities with Thibet, and finally with China. The Teshoo Lama of Thibet having proceeded to Pekin, died soon after his arrival in that city. His brother, Sumhur Lama, taking advantage of his absence, fled from Lassa to the rajah of Nepaul, carrying along with him a considerable quantity of treasure; and he made such representations to the Nepaul government that their avarice was inflamed, and having marched a body of troops to Lassa, they extorted from the lama a tribute of three lacs of rupees. In 1790 they despatched to Teshoo Loomboo, the residence of another sacred lama, a second body of troops, amounting to 7000 men, who pillaged the place and the sacred temples, and succeeded in carrying off a large booty, though closely pursued by a Chinese army, and though, from the severity of the weather, they lost 2000 men in their retreat. The emperor of China, as the terrestrial superior of the lamas, and their worshipper and protector, incensed by these unprovoked aggressions, despatched an army of 70,000 men against the Nepaulese, who were overthrown in repeated battles; and the Chinese army advanced to Noakote, within twenty-six miles of Catmandoo, and sixty of the British territory of Bengal. A peace was at last concluded, though on terms ignominious to the Nepaulese, who were compelled to become tributaries to the Chinese, and to refund the spoil which they had taken from the Thibet lamas. It does not appear, however, that this tribute was ever exacted. It was about this period that Lord Cornwallis attempted to conclude a treaty of commerce with the Nepaulese; but every proposition of this nature was frustrated by their extreme jealousy. Nepaul.

The queen-regent died in 1786, when the care of the young rajah devolved entirely on his uncle Bahadur Shah, who was accused of having, from disgraceful motives, encouraged the rajah in his debaucheries, in hopes of bringing him into contempt, and of thus securing to himself the reins of authority. In this expectation, however, he was deceived, as the rajah, in 1795, when he had entered into his twentieth year, suddenly announced to his uncle that he had now resolved to assume the reins of government, and being supported by a large proportion of the nobles, Bahadur Shah, making a virtue of necessity, forbore all resistance, and received in return assurances of the most distinguished favour. The young rajah rendered himself extremely popular during the first year of his reign. But this fair prospect was speedily overcast, and the youth plunged into all the excesses of the most furious despotism and cruelty. His first act was to arrest his uncle, and, loading him with chains, to throw him into prison, where he was starved to death. He daily tortured and mutilated his subjects, and beheld their sufferings with savage joy. In his outrages he made no distinction of age or sex. Women of all castes, even those belonging to the sacred orders, were seized, and subjected to abuse from the vilest characters. In 1797, he had a son by a brahmin widow, who being taken seriously ill next year, and finding her end approaching, reminded the rajah of the prediction of astrologers, that he would never complete his twenty-fourth year, and entreated that he would provide for the unprotected orphan they were about to leave. The rajah, relying implicitly on the superstitious prophecy, immediately, and in the most solemn manner, before all the chiefs, abdicated the throne in favour of his son, though illegitimate, and an administration was then appointed, over which one of his ranees or queens was appointed to preside. The abdicated monarch now devoted his whole time to attendance on his favourite widow, who, notwithstanding all his attention, and rich offerings at the different temples, soon afterwards expired. In his affliction he became quite frantic, and perpetrated atrocities, the bare mention of which causes the Nepaulese still to shudder, and which are too shocking to be narrated. Amongst various enormities, he directed the sacred temple of Bahvani to be demolished, and the golden idol, which was a venerated object of worship, to be ground to dust; and when the soldiers to whom he had issued the orders demurred at such an act of sacrilege, he commanded boiling oil to be poured on their naked bodies. Nor were any exempt from his rage. Neither rank nor caste afforded any protection from his violence. Even the first members of the government were scourged without mercy, and otherwise tortured. A confederacy was at last formed against the tyrant, who finding himself abandoned, absconded during the night, and fled to Benares, which he reached in May 1800.

A close connection with Nepaul had always been a favourite object with the British rulers of India, and the flight of the rajah to Benares appeared to present a fair opportunity for bringing it about. A treaty of alliance was accordingly concluded between the two states, by Captain W. D. Knox, who was appointed ambassador,

Nepaul. and who proceeded to Catmandoo for the purpose in 1802. The terms of the treaty were considered as favourable to the British interests; the Nepaulese being anxious to secure the influence of such powerful neighbours against the faction of the abdicated rajah, who still contended for his restoration. But whatever advantages were attained by this treaty, were ultimately rendered nugatory by the jealous opposition of the subordinate officers amongst the Nepaulese, who were probably instigated by their chiefs, the latter being entirely unable to fulfil the obligations which they had entered into.

The residency at Catmandoo was accordingly withdrawn in the year 1804. About this time the abdicated monarch, Run Bahadur, by the able management of his queen, whom he had always ill treated, was restored to his former authority. But as he continued to rule with his former barbarity, his reign was of short duration; in 1805 a conspiracy was formed against him, which terminated in his assassination. His death was succeeded by the most violent conflicts between the adverse parties in the state, and did not terminate until nearly the whole of the nobles at Catmandoo had perished. The surviving adherents of the late rajah having at length secured the person of his son, seized on the reins of government, putting to death such of the opposite party as still remained.

But during all these intestine commotions, it is remarkable that the Nepaulese still extended their conquests on every side. To the west of Catmandoo, and towards the Sutlege, the hill-chiefs were distracted by mutual jealousies, and by no means in a condition to form a league for their mutual defence. They were accordingly subdued one after another by the armies of the Ghoorkhas, who very soon made themselves masters, without the aid of artillery, of every hill-fort, from the Ganges to the Sutlege. When their movements first attracted the notice of the British government, their chief was vigorously prosecuting the conquests of these states; and as he advanced westward, he erected strong forts and stockades at convenient positions, namely, Almorah, Serinagur, and Malowa. The Sikh frontier was also guarded by a strong line of fortified posts; and thus the consolidation of the Ghoorkha empire proceeded with a slow but sure progress. The extensive tract which lies between Catmandoo and the Sutlege was held in firm subjection by a strong military force, whilst to the east the Sikkim rajah was deprived of half his territories, and compelled to pay a tribute for the remainder. To the north the progress of conquest was restrained by the Chinese power, with which the Ghoorkha chiefs had already found themselves unable to cope, and also by a lofty range of barren mountains. But the fertile and low situated plains of the south presented a more alluring prospect, and greater probabilities of success in a contest with a new and untried power. The consequence was a series of encroachments along the whole northern frontier of the British possessions, especially in the district of Gorruckpoor and Sarun. The British remonstrated against these proceedings, and an investigation into the respective claims of the two powers was commenced by commissioners jointly chosen, the result of which being entirely favourable to the British, a detachment of regulars was ordered to take possession of the debateable ground. But these being withdrawn during the rainy season, the chief police station upon the frontier was attacked by large bodies of Nepaulese, and the officers were compelled to fly, with a loss of eighteen killed and six wounded. Shortly afterwards a second attack was made on another police station, and several persons were killed, after which the whole body was withdrawn; and, in 1814, the war commenced. A brief account of the operations of this war will be found under the article HINDUSTAN; and it is only necessary here to state generally, that the invasion of the Nepaulese dominions was commenced on the western frontier, beyond the Jumna and near the Sutlege, the country there being considered as of easier access than the mountainous barrier which bounds the Nepaulese dominions on the side of Bengal. But the British troops, in attempting to storm the stockades and hill-forts, were repeatedly driven back with severe loss, and suffered reverses to which they had been wholly unused in the wars of India. Here it was that the brave General Gillespie was slain, whilst he was encouraging his troops, who had been repulsed, to renew the attack. In 1815, Sir David Ochterlony assumed the chief command, and by a series of skilful operations, in which he dislodged the Ghoorkha troops from the fortified heights of Malowa, and ultimately so hemmed in their renowned commander Ameer Singh, and his son, that they were forced to sign a capitulation, by which they agreed, on being permitted to retreat with their remaining troops, to abandon the whole territory west of the Cali branch of the Goggra. In Kumaon also the British troops succeeded in driving the enemy before them; and, in consequence of these successes, a definitive treaty of peace was signed on the 28th of November 1815. But the signature of the rajah being withheld, it was determined to renew the war, and to strike a decisive blow directly at the capital of the country. Preparations for this arduous enterprise were made on a great scale, a force being assembled at Sarun amounting to about 13,000 men, of whom 3000 were Europeans, besides a large body of irregulars, amounting in all to above 46,000 troops. This formidable force took the field in the end of January 1816, and advanced from the Bettiah district directly on Catmandoo. The greatest difficulties were encountered, from the ruggedness of the country, in marching along the dry beds of torrents, through ravines, and in the face of precipices. But all these obstacles were overcome by the patience of the troops, and the consummate skill and science of their commander. The Ghoorkhas made a brave resistance, but they were overthrown in several severe encounters; and the British force had now approached within three days' march of their capital, Catmandoo. Deeming all further resistance vain, an ambassador was sent to the British head-quarters, to sue for peace; and the unratified treaty of the year 1815 was accordingly duly signed. By this treaty the Nepaulese renounced all claims to the territory in dispute. They also ceded all the conquests which they had made to the west of the Cali branch of the Goggra, and which, with the exception of Kumaon, the Deyrah Doon, and some other portions of territory annexed to the British dominions, were restored to the families of the chiefs who had reigned there prior to the Ghoorkha invasion, and who were now to rule as vassals of the British; it being understood, however, that the latter were not to interfere in the internal administration, but were merely to act as arbiters between rival chiefs.

In the course of this contest with the British, the Nepaulese had earnestly entreated the aid of the Chinese against the Europeans, whom their ambassadors represented as desirous of acquiring Nepaul merely to serve as an intervening point in their progress to China. Their application being transmitted by the grand lama to Pekin, an answer was received, in which the emperor expressed his conviction that the Ghoorkhas had themselves been the cause of the war by their unjust encroachments, and declined all interference. After peace was concluded, the Chinese emperor expressed deep offence against the rulers of Nepaul, who, being merely tributaries, had presumed to make war or peace with the British, without the sanction of their superior; and, to back those lofty pretensions, an army of 15,000 men, commanded by five generals, and attended by Chinese functionaries of superior rank, usually stationed at Lassa, actually advanced towards the Nepaulese territories. At the request of the Nepaul ministers,

Nepos.

the British consented to act as mediators. But in the meantime they themselves despatched to the Chinese camp agents, who having reached it early in September 1816, succeeded in bringing about the restoration of peace, and of all the ancient relations between the two powers. In 1816 Ameer Sing Thappa, one of the most distinguished Ghoorkha commanders, who had so gallantly disputed the field with Sir David Ochterlony, died at the age of sixty-eight. To the last day of his life he was endeavouring, by negotiation and by every art, to excite amongst the different states a spirit of hostility against the British, as the common enemies of Indian independence. Two of his widows devoted themselves to death along with him; one sacrificed herself on the spot, and the other was at the same time preparing for the fatal pile at the temple of Pushpoonath, within the valley of Khatmandu. In November 1816 the young rajah died of the small-pox, at the age of twenty-one years. One of his queens and one of his concubines, together with five female attendants, devoted themselves to the funeral pile along with the corpse. He left one son, three years of age, named Rajindra Bickram Shah, who succeeded quietly to the throne, under the guardianship of the minister Bheem Singh Thappa; a very unusual circumstance in the annals of Nepaul. From this time the history of Nepaul presents little that can excite interest in a European mind. Intrigue, and occasional resort to rougher means, identify its character with that of most Asiatic courts. At intervals, however, events have occurred which, by their unusual atrocity, relieve the tameness of the surrounding incidents. Such events have marked the career of the present prime minister, Jung Bahadoor, whose name is well known in England, which country he visited some years since. Jung Bahadoor was the nephew of a man who had elevated himself to a high position in the administration of affairs. Upon the murder of his uncle, which was perpetrated at the instigation of the queen, a new ministry was formed, and Jung was appointed to the command of the army. Shortly afterwards, the new premier was assassinated, and the queen, with whom he was a prime favourite, demanded vengeance. Jung Bahadoor undertook the task, and executed it with alacrity. An assembly of chiefs and nobles being convened within the palace, Jung, backed by a small force on which he could depend, suddenly appeared among them, and a general massacre raged throughout the building. Fourteen of the hostile chiefs fell by the hand of the commander-in-chief; but the bodies of his victims were for Jung the stepping-stones to power. Before the dawn of the succeeding day Jung Bahadoor was invested with the office of prime minister. His future career was not inconsistent with its commencement. A conspiracy was formed for his destruction; but Jung not only escaped, but seized and beheaded all the adherents of the chief conspirator. The queen was banished with her two younger sons, and the king having accompanied them, the heir-apparent was raised to the throne. A feeble attempt was made by the monarch to regain his throne, but the energy of Jung baffled it, and the king was made prisoner. Jung Bahadoor has always professed a friendly feeling towards the British; and at the commencement of the great military revolt in 1857 (the particulars of which will be found under the article North-Western Provinces of Bengal), he proved the sincerity of his friendship by reinforcing the British army with a contingent of Ghoorkha troops. (D. B—N.) (E. T.)

NEPOS, Cornelius, a Latin writer, who was the friend of Cicero, Atticus, and the poet Catullus, and flourished B.C. 40. It is uncertain where he was born, but Pliny (iii. 22, 2) calls him *Padi accola*; and his friendship with Catullus makes it not improbable that Hostilia, near Verona, where that poet was born, was also his birth-place. We possess no information respecting his private life; but many of his works are cited by later writers. 1*st*. His *Chronicles* or *Annals*, probably in three books, of which the fragments do not enable us to decide whether they were confined to the history of Rome, or included that of all nations. Some have asserted that this was a mere translation of the work of Apollodorus on the same subject; but they have no sufficient grounds for so believing. 2*d*. The *Exemplorum Libri*, of which the fifth book is cited by Aulus Gellius (vii. 18), and which seems to have been a work containing remarkable transactions selected from history; but this may have been only another title for his work. 3*d*. The *Lives of Illustrious Men*, of which the sixteenth book is cited, and the lives we now possess, no doubt formed a part. 4*th*. The *Lives of Historians* (Nep. Dion. iii.), which included both Greek and Latin. It seems not unlikely that the biographical sketch still remaining of Atticus, and the longer one of Porcius Cato, which he mentions (Cato, iii.), belonged to this collection. 5*th*. The *Letters to Cicero*, which must have been published, as some of them are quoted by Lactantius (*Inst.* iii. 15). It would appear that he had also made successful attempts in poetry (Plin., *Ep.* v. 3). We possess a work under the name of Nepos, *Vitæ Excellentium Imperatorum*, which is not mentioned by any ancient writer under this title. It contains short biographical sketches of twenty commanders, mostly Greek; an essay, *De Regibus*, which is little else than the mere names of Greek and Persian kings; and the lives of Hamilcar and Hannibal. There are also two other biographical sketches of Atticus and Cato, which used to be separated from the rest, because they were not found in all the manuscripts, or, when found, were entitled *Ex libro Corn. Nepotis de Latinis Historicis*; whilst the others used to be considered as the work of a certain Æmilius Probus, whose name was found in all the manuscripts. This Æmilius Probus was long considered as a contemporary of Nepos; but he is now generally believed to be the *præfectus prætorius* to whom Ausonius addresses his sixteenth epistle, and is supposed to have lived in the reign of Theodosius, A.D. 370. At first, however, this work appeared under the name of Probus, and was thus published in 1471, and in the following editions, till 1563. Gifanius, in 1566, first directed the attention of the literary world to Nepos as the author; and subsequent investigation has nearly set the question at rest. Attempts have, however, been made to revive the old opinion, on the authority of the manuscripts and of the poetical address or dedication, on the silence of ancient writers to whom these lives seem to have been unknown, on several mistakes in history and chronology which appear in the work, and on the language, which is alleged to be unworthy of the golden age of Roman literature. (See the dissertations on this controversy prefixed to the editions of Lambinus (1569), Titze (1813), Bardili (1820), Dähne (1827), Roth (1841), and Benecke (1843). The most useful editions are those of Van Staveren (1773), Tzschucke (1804), Bremi (1820), and particularly Lemaire (1820). These biographies have always been exceedingly popular as a school-book; and the translations of them into various languages are numberless. The first English version was executed by "various gentlemen of the university of Oxford," London, 1684.)

Nepos ‖ Neptune.

Nepos, *Julius*, a Roman emperor of the West, was invested with the purple by Leo I. in 473, was expelled from the throne by Orestes in 475, and was assassinated near Salona by two of his own officers in 480. (See Roman History.)

NEPTUNE (in Lat. *Neptunus* or *Neptumnus*, in Gr. *Poseidon*), the god of the sea, was the son of Kronos and Rhea, and the brother of Jupiter and Juno. The etymology of the Greek as well as of the Latin form of his name is very obscure and doubtful. The ancient Dorians wrote the word *Poteidan*, in which some scholars find the same root as in *Potos* and *Potamos*, and the verb *pino*.

Nerbuddah ‖ Neri.

Cicero derives the Latin name of the deity from the Greek *nao*, the Latin *nato;* Varro, with still less show of probability, from *nubo* or *obnubo*, on the ground that the god covers or surrounds the earth with his waters. The most feasible explanation seems to be that which connects the name Neptunus with the root *nip*, as found in the Greek *nipto*. When the dominions of Kronos were divided among his sons, the sea fell to Neptune as his share. He was therefore worshipped with peculiar solemnity by all maritime nations; from the earliest ages by the adventurous Ionians, and at a later period by the Dorian Greeks. His favourite abode was said to be a splendid submarine palace at Ægæ. Among the principal seats of his worship may be mentioned Cyrene, Ægina, Corinth, and Trœzen, whence it was transferred to the Italian peninsula, first to Sybaris, and afterwards to Posidonia or Pæstum. The Isthmian games, held in his honour at Corinth, ranked among the four national festivals of the Greeks. (See ISTHMIA.) Neptune plays an important part in some of the ancient myths. He helped Apollo in building the walls of Troy for Laomedon. In his contest with Minerva for the honour of giving name to the city of Athens, he produced the horse. On this account he was regarded both by Romans and Greeks as a kind of equestrian as well as marine deity. The Romans had horse-races in the circus during his festival, when all other horses were crowned with wreaths and allowed a short respite from labour. The animals most commonly sacrificed in his honour were bulls, rams, and boars. Besides his favourite Amphytrite, by whom he had his son Triton, Neptune had two other wives, Salasia and Venilia. His statues represent him as a heavy and powerful figure, with tangled hair, and inferior in dignity of expression to his brother Jove. In his right hand he holds the trident, and with his left guides the horses yoked to the shell which serves him for a car. A long train of tritons and sea-nymphs follows in his wake.

NERBUDDAH, a large river of Hindustan, rising in the province of Gundwana, which, after a course of 750 miles, falls into the Gulf of Cambay. This river has its source close to that of the Soane, on the elevated plateau of Amarakantak, or Omercuntuc, at an elevation of between 3000 and 4000 feet above the sea. A Hindu temple is found in the centre of the table-land at Omercuntuc; and here the Nerbuddah rises from a small well, and flows easterly in a smooth stream until it is precipitated from the brow of the table-land. From this point its course is due W., with the straightest course of any river perhaps in the world. It passes through Gundwana, Khandesh, Madwah, and Guzerat, and after passing the city of Broach, falls into the Gulf of Cambay, in Lat. 21. 35., Long. 72. 35. This river was in former times the boundary between Hindustan proper and the Deccan or southern peninsula. Ships of burthen can proceed up the river to Broach, where it is a noble sheet of water 2 miles wide, even when the tide is out; but skilful pilotage is necessary in consequence of numerous sand-banks. The practicability of improving the navigation by artificial means has been considered, and some years since instructions were sent out for a survey by a competent officer with a view to this end.

NEREIDS. See NYMPHS.

NEREUS, a sea-god, son of Pontus and Ge, and father of the Nereids, the marine nymphs of the Mediterranean. His wife was Doris, the daughter of Oceanus. He is described as a wise and kindly deity, and especially skilled in divining the future. (Hor., lib. i., carm. 15.) His favourite haunt was the Ægean Sea, in which he lived with his daughters. The number of these nymphs is variously given as fifty or a hundred. (See NYMPHS.)

NERI, FILIPPO DE, the founder of the congregation of the "Priests of the Oratory," was born of a noble family in Florence in 1515. From his childhood he was noted for a kind and pious disposition. This trait in his character began to appear in greater distinctness when he had completed his elementary education, and removed to Rome at the age of nineteen. But it was not until his twenty-fourth year that his religious charity assumed the form of active Christian philanthropy. At that time he abandoned his classical and theological studies, sold his books that he might give the money to the poor, and resolved to devote the rest of his life to doing good to the bodies and souls of his fellow-men. A deep sense of sin would not permit him to enter into holy orders. He was therefore content, in the unconsecrated garb of a layman, to relieve the needy, to console the sick and the dying, to visit the prisoners in their cells, to plead the cause of the oppressed in the courts of justice, and to instruct the ignorant in the street and by the wayside. The most notable of his many benevolent deeds at this time was the erection of an asylum for sick and destitute strangers. In 1551 Neri, being persuaded at length to enter the church, saw the circle of his influence beginning to widen. Several young ecclesiastics, including Baronius and others, who were afterwards celebrated, began to gather around him, and to aid him in his philanthropic labours. These he formed, in 1564, into an order, which, from the Italian name for a chapel, was called the "Congregation of the Priests of the Oratory." He laid upon them no monastic vows, but trusted that the common spirit of charity by which they were animated would be a living bond of union between them. The new order soon became distinguished for its Christian zeal and enterprise. In 1575 Pope Gregory XIII. recognised its usefulness by formally bestowing upon it his sanction. Its founder had the satisfaction in his old age of seeing it established in the principal Italian towns. In 1593 he resigned the generalship of the Oratory in favour of Baronius. He died in May 1595. Filippo de Neri was canonized by Gregory XV. in 1622. His Life has been written in Latin by Gallonio, 8vo, Rome, 1602; and by Bacci, 4to, Rome, 1645. His letters were published in 8vo, Padua, 1751; and his treatise called *Ricordi*, and several of his poems, appeared in the *Rime Oneste*.

Nerja ‖ Nero.

NERJA, a town of Spain, province of Malaga, on the Mediterranean, 13 miles E. of Malaga. It is well and regularly built, with broad paved streets and three squares; and has a parish church, a town-hall, and three schools. Manufactures of flour, sugar, linen, and paper, are carried on; and there is some trade in corn, oil, sugar, and fish. Pop. 4595.

NERO, a cognomen of the gens Claudia, one of the most illustrious patrician families of ancient Rome. The word, according to Suetonius, is of Sabine origin, and signifies "fortis" and "strenuus." Thus, *Nerio*, *Nerio*, or *Neriene*, personified "Bravery," was the name of the companion and wife of Mars; and in the Umbrian language, the often-recurring *Nerf* or *Nerfr* is explained *princeps*. The most distinguished persons who bore this name were,—

1. *C. Claudius Nero*, who signalized himself in the second Punic war by his successes against Hannibal, and, above all, by his splendid victory at the Metaurus (B.C. 207) over Hasdrubal, which completely broke the Carthaginian power in Italy.

2. *Claudius Drusus Nero*, the stepson of Augustus, and younger brother of the Emperor Tiberius. In the year B.C. 15, Drusus Nero, then only in his twenty-third year, subdued the Rhæti and Vindelici, and during his consulship, six years later, commanded the Roman armies in Germany, where he died. His wife was Antonia, the daughter of Mark Antony the triumvir, and by her he had three children, Cæsar Germanicus, the Emperor Claudius, and Livilla. (Hor., lib. iv., carm. 4.)

3. *Claudius Cæsar Nero*, the sixth of the Roman emperors. His original name was Lucius Domitius. His father

Nertshinsk || Neston.

was Domitius Ahenobarbus, and his mother Agrippina, the daughter of Germanicus. He was born at Antium in Latium A.D. 37, succeeded Claudius as emperor A.D. 54, and died A.D. 68, in the thirty-second year of his age and fourteenth of his reign. (See ROMAN HISTORY.)

NERTSHINSK, a town of Siberia, in the Transbaikalian territory, at the confluence of the Nertsha and the Shilka, 540 miles E. by S. of Irkutsk, and about 400 E.N.E. of Kiachta. It is wretchedly built of wood, and consists of an old and a new town, at some distance from each other. There are several churches; and some trade is carried on in furs. The district of Nertshinsk is rich in mines of gold, silver, and lead, in which a great number of men are employed. It also affords good pasturage. Pop. of the town (1851) 4993.

NERVA, MARCUS COCCEIUS, the thirteenth emperor of Rome, was born at Narnia in Umbria A.D. 27, or, according to other authorities, in A.D. 32. He succeeded to the purple on the assassination of Domitian, September 18, A.D. 96, and, after a mild and equitable reign of sixteen months and nine days, died early in the spring of A.D. 98. Before his death he had adopted Trajan as his successor. (See ROMAN HISTORY.)

NERVES. See ANATOMY, and PHYSIOLOGY.

NERVII, a nation of Belgica, whose territory was situated N. of the Ambiani, are first mentioned by Cæsar at the date 57 B.C. At that time they were a simple-living, warlike, and patriotic people, abjuring all commerce with other nations, prohibiting wine and other luxuries from being imported into their territory, and zealously stirring up their neighbours to resist the coming invasion of the Romans. On receiving intelligence that Cæsar was advancing into their country, they sent away their old men, women, and children to a place of refuge among the marshes by the sea-shore, and posted themselves in ambush on the banks of the Sabis (*Sambre*). The invaders had approached close to the place of concealment, and, unsuspicious of any danger, were engaged in forming a camp, when they suddenly found themselves attacked by 60,000 fierce barbarians. The Romans would have been immediately routed, had not the invincible genius of Cæsar been there to sway and turn the tide of battle. After a hard-fought contest, the Nervian forces were almost annihilated; but the Nervii were not yet subdued. They are found, in 54 B.C., assisting the Eburones in the unsuccessful attack upon the camp of Quintus Cicero; and it was not until the following year that they finally submitted to the Romans. The Nervii possessed two important towns,—Bagacum (*Bavai*), their capital; and Camaracum (*Cambrai*).

NESS, LOCH, a lake of Scotland, in the county of Inverness, stretching from S.W. to N.E. for nearly 24 miles, with an average breadth of a mile and a quarter. It is fed by the River Oich, from Loch Oich, and by several other streams, of which the largest are the Moriston, the Foyers, and the Farigag. The depth of the loch near the centre is from 100 to 130 fathoms, its bottom being below the level of the sea; and owing to its great depth the water never freezes. The mountains on either side of the loch are lofty, rugged, and steep, rising to the height of 1200 or 1500 feet above the sea. The waters of the loch are conveyed to the sea by the River Ness, which falls into the Moray Firth at Inverness. Loch Ness is connected by the Caledonian Canal with Inverness on the N.E., and with Loch Oich on the S.W.

NESTON, GREAT, a town of England, county of Chester, near the shore of the estuary of the Dee, 11 miles N.W. of Chester. It has an ancient church with a handsome front and a tower; Methodist, Independent, Calvinist, and Roman Catholic churches; and several schools. The town depends chiefly for its prosperity on the summer visitors, who resort hither for the sake of the sea-bathing. Pop. (1851) 1524.

NESTORIUS, the founder of the sect of the Nestorians, was born at Germanicia in Syria towards the close of the fourth century. After receiving his education in a convent, he was ordained a presbyter of Antioch. It was there that he imbibed the doctrine of the Syrian church, which held, in opposition to the Egyptian church, that the two natures of Christ were distinctly separate, and were united into one person by a certain relation. His simple and austere habits, his devotion to the cause of the church, and his fervid and winning eloquence, marked him out in no long time as a fit champion of the tenets he had adopted. An opportunity soon occurred for the exercise of his zeal and influence. In 428 he was promoted to the patriarchate of Constantinople. "Help me to subdue the heretics, and I will help you to subdue the Persians," was the fanatical boast by which he indicated to the emperor his intention of immediately commencing a vigorous course of proselytizing. Not content with persecuting the Arians, Novatians, and Quartodecimanians, he soon discovered in the current speech of the city an expression which savoured of the peculiar doctrine of the Egyptian church. That was the epithet "the Mother of God," a phrase which he alleged to imply the deification of the human nature of Christ, and which he therefore condemned. From this incident arose the famous Nestorian quarrels. The Constantinopolitan patriarch forthwith found himself engaged in hot controversy with several of his monks and clergy. They accused him of Photinianism; he accused them of Manicheism. They preached against him in the churches, and renounced their ecclesiastical allegiance; he turned them out of the churches, and deposed them. At this crisis, Cyril, the meddling and arrogant Patriarch of Alexandria, eager for an opportunity to bring down a powerful brother-bishop, insinuated himself into the contest, and changed it from a mere local squabble about a name of the Virgin Mary into a serious controversy touching the respective doctrines of the Syrian and Egyptian churches. After solemnly professing to be actuated solely by love for the true faith, and after employing the most gross deceits to maintain this profession, he organized a strong opposition against Nestorius, and at length, by artful flattery, he obtained from Pope Cœlestine I. the power of dealing with the alleged heresiarch. Convening a council at Alexandria in 430, the Egyptian patriarch launched twelve anathemas at the head of Nestorius. Nestorius hurled back twelve other anathemas. This rupture was fast growing into a schism, when the emperor, Theodosius II., anxious to restore the peace of the church, summoned the third œcumenical council to meet at Ephesus in 431. Nestorius repaired thither, trusting to the justice of his cause; but that, he soon found, was a frail offset against the shameless machinations and powerful influence of his adversary. He was summoned to the bar before his friends the Antiochian bishops had arrived; he was deposed on the charge of blasphemy before he had pled his cause; his appeal to the emperor was counteracted by misrepresentations; those who were favourable to him at court were overawed by a fanatical mob artfully raised by his indefatigable foes; and at length he was glad to escape from the ever-thickening broil by retiring to the cloister of Euprepius near Antioch. There the heresiarch enjoyed peace for four years. But by that time some of his former friends had taken up the cry against him, and, afraid lest he should communicate the taint of heresy to those around him, they resolved to cast him, like a pestilential carcass, beyond the pale of civilized society. He was accordingly banished to the Greater Oasis in Upper Egypt. But even in that solitary retreat no rest was to be found. He was soon obliged to flee before the invasions of the barbaric Blemmyes, and to take refuge in the Thebaid. Then the old man, at the command of the Roman governor of that district, was dragged about by a savage soldiery from one place to

Nesotrius.

Nestorius.

another, until death closed his long career of troubles. The date of his demise is unknown.

Meanwhile, the favourers of Nestorius, or, as they were called, the *Nestorians*, were becoming numerous in the provinces of the East. The writings of the exiled patriarch, and of Theodore of Mopsuestia, translated into Syriac, were already circulating through Assyria and Persia, and making many converts. As early as 435 the celebrated school of Edessa had become the seminary of Nestorianism, and was sending forth numerous disciples zealous for the new doctrine. The most famous of these was Barsumas, the indefatigable and politic Bishop of Nisibis. In conjunction with Maanes, Bishop of Ardaschir, he prevailed upon the Persian king Pherozes to establish the Nestorians as the national church of Persia. A great stimulus was thus given to the sect. Patronized by the state, they made Seleucia the seat of their patriarch, and established an excellent seminary at Nisibis. Isolated from other Christians, and therefore forced to maintain a distinct and real individuality, they began to make their peculiar creed something more than a mere repudiation of the epithet "Mother of God." Accordingly, at a synod convened by the Patriarch Babæus at Seleucia in 496, a system of doctrine was framed and adopted. The characteristic dogmas of this system were, that in Christ there were two persons, the Divine Logos and the man Jesus; that these two persons were united together by no other connection than that of will and affection; that Christ, on that account, ought to be clearly distinguished from God; and that these tenets had not been derived from Nestorius, but had been held by the church from her infancy. Another peculiar opinion was, that it was lawful for bishops and presbyters to marry. Having thus obtained a constitution of its own, Nestorianism started on a long career of prosperity and activity. It was regarded with favour, or at least with toleration, under the Saracens, Arabs, and Tartars, the successive masters of Persia. Its missionaries travelled over all Northern Asia, and as far west as China, evangelizing the heathen, and planting numerous churches. At length, in 1551, it received a severe check, and its members were divided into two factions, by a dispute regarding the election of a patriarch. One party elected Sulaka, placed themselves under the jurisdiction of the Roman pontiff, and were afterwards known by the name of Chaldean Christians. The other party have continued till the present day to be the true representatives of the primitive Nestorian church in Persia. They are at present a simple, poor, illiterate, yet independent people, amounting to about 140,000, and living around Diz, the seat of their patriarchate, among the mountainous ranges of Kurdistan. Subjected for many ages to the proselytizing influence and persecution of Papists and Mohammedans, they have not escaped the infection of superstition. Their patriarch and their eighteen bishops are doomed to celibacy and perpetual abstinence from animal food; many fasts are observed; a peculiar religious festival in commemoration of the dead is held annually; and charms and talismans are often distributed by the clergy among their flocks. Yet their system of doctrine is free from all the more gross and deadly errors of the church of Rome. The Bible is recognised as the supreme and sole canon of faith; the inferior clergy are permitted to marry; and auricular confession, image-worship, and the belief in purgatory, are abjured. There is also a body of Nestorians existing in India, under the name of Syrian Christians, and acknowledging the jurisdiction of a patriarch. They abound to the number of 100,000 in Travancore, and are also numerous in the neighbourhood of that state. Although ignorant and superstitious, they are said to be essentially orthodox, and are on terms of friendly intercourse with the English prelates of India.

Several sermons, epistles, and fragmentary writings of Nestorius, and other papers relating to the Nestorian quarrels, are published in the works of Marius Mercator by Baluze, 8vo, Paris, 1684. The most recent treatises on the subject are,—Perkins's *Eight Years' spent among the Nestorian Christians*, New York, 1843; Badger's *Nestorians and their Rituals*, in 2 vols. 8vo, London, 1852; and Marsden's *Christian Churches and Sects*, in 2 vols., London, 1856.

Nesvish || Neubur

NESVISH, a town of European Russia, in the government of Minsk, on the Usha, 60 miles S.W. of Minsk. It is protected by fortifications, which, however, are in a very dilapidated state; and it has a Benedictine abbey. Pop. 4230.

NETHERLANDS. See HOLLAND.

NETSCHER, GASPAR, an eminent painter, was born, according to one account, at Heidelberg in 1639, but according to another, at Prague, in 1636. His father died when he was two years of age; and his widowed mother, fleeing from the dangers of a civil war, carried him to Arnheim. There the young orphan was adopted and educated by a benevolent physician named Tullekens. At first he was destined for the profession of his patron; but his great aptitude for painting soon caused the plan of his future career to be altered, and he was placed under an artist named De Koster. After a short time spent in painting birds and objects of still life, the pupil had exhausted all his master's instructions, and set out for Italy to complete his education there. Happening, however, to get married at Liège, and being compelled to practise his art for the support of his household, he could proceed no farther. He settled at Bordeaux, and toiled hard to earn a livelihood by painting fancy subjects. But those small cabinet pictures, which are now so highly valued on account of their exquisite finish, brought but a small remuneration; and after removing to the Hague, he turned his attention to portrait-painting. In this branch of his art he was more successful. His earnings soon became so considerable, that he was enabled at times to gratify his own taste and fancy by depicting musical and conversational pieces. It was in these that Netscher's genius was first fully displayed. The choice of the subjects, and the habit of introducing female figures, dressed in rich, glossy satins, were imitated from Terburg; but the easy yet delicate pencilling, the brilliant yet correct colouring, and the complete mastery over light and shade were all his own. He soon attracted notice, and was rapidly gaining both fame and wealth, when he was cut off at the premature age of forty-one. Many of Netscher's pictures may be found in the galleries of the Louvre, Hesse-Cassel, Berlin, Dresden, Munich, and Florence; at the Hermitage in St Petersburg, and in the English collections of Sir Robert Peel, Mr Hope, Lord Ashburton, and the Earl of Bridgewater. The style of Netscher was imitated by his two sons Theodore and Constantine; but these, though meritorious painters, were far inferior to their father.

NEU-BRANDENBURG, a town in the duchy of Mecklenburg-Strelitz, on the shore of Lake Tollen, 55 miles W.N.W. of Stettin. It is regularly built, and surrounded by walls, through which entrance is obtained by four gates. The principal buildings are the palace of the grand duke, a long, low building in the market-place; and the church of St Mary, a fine Gothic edifice, lately restored, which contains some good paintings. This town contains two other churches, several schools, a town-hall, and a theatre. It has manufactures of tobacco, paper, cards, leather, &c.; and carries on a considerable trade in these articles, and in horses and hides. An annual fair for wool is held here, and there are also horse races. Pop. 6145.

NEUBURG, a town of Bavaria, in the circle of Suabia, stands on the right bank of the Danube, 33 miles N.N.E. of Augsburg, and 45 N.N.W. of Munich. It is an old town, picturesquely situated on a wooded hill that rises from the river's side. Besides the town itself, which con-

Neuchâtel. sists of an old and a new part, and is partly walled, there are two suburbs. The ancient castle, formerly the residence of the dukes-palatine of Neuburg, is surrounded by a fine garden, and contains a collection of portraits, old armour, tapestry, &c. There are in the town three churches, a convent, a college (which formerly belonged to the Jesuits), several schools, a public library, museum, town-hall, barracks, arsenal, infirmary, and orphan hospital. Beer, brandy, earthenware, cloth, and saltpetre are the principal articles manufactured here; and fishing is also carried on to some extent. On an island in the river are the ruins of the ancient castle of Altenburg; and in the neighbourhood of the town are two residences of the King of Bavaria. The Danube is here crossed by two bridges, under which steamers pass by lowering their funnels. Pop. 6350.

NEUCHÂTEL, or NEUFCHÂTEL (Germ. *Neuenburg*), a canton of Switzerland, lying on the N.W. shore of the lake of the same name, between N. Lat. 46. 50. and 47. 10., and E. Long. 6. 25. and 7. 5. It is bounded on the N.E. and E. by the canton of Bern; S.E. by the Lake of Neuchâtel, which separates it from Fribourg and Vaud; S. by Vaud; W. and N.W. by France. Its length is about 30 miles, average breadth 11 miles; area 280 square miles. The surface of the canton is mountainous, being traversed through its whole length by the Jura Mountains. It consists of three different regions, distinct from each other in nature and appearance. The lowest part of the canton is that which extends along the shores of the lake, and is known by the name of Vignobles. This tract of country is for the most part planted with vines, and has an elevation of 1400 feet above the sea. The centre of the canton comprises a tract of land inclosed between two parallel ridges of the Jura, and is elevated from 2000 to 2400 feet above the sea. This region is known by the name of Vallon, and includes the Val de Travers and the Val de Ruz. Corn, pulse, grass, and fruits are grown here. That part of Neuchâtel which lies on the borders of France is called the Montagnes, and consists of the lofty ridges of the Jura and the high-lying valleys by which they are separated. These valleys are called La Chaux de Fond, Locle, La Chaux du Milieu, La Brevine, and La Sagne, respectively. The highest peak of the Jura within this canton is that of Chasseral, which has an elevation of 5285 feet. The canton contains numerous small streams, each of the valleys having at least one, to which it gives name; and, besides these, Neuchâtel is partly bounded by the Doubs on the French frontier, and by the Thielle, which joins the lakes of Bienne and Neuchâtel on the frontier of Bern. The climate of the different parts varies very considerably,—in the lower regions it is mild enough for the growth of the vine, but in the uplands it is very cold and bleak, the snow lying on some of the heights for seven or eight months in the year. The geological structure of the country is almost entirely calcareous, consisting of a kind of rock known by the name of Jura limestone. The only valuable mineral that is obtained in Neuchâtel is iron. The corn produced in the canton is not sufficient to supply the wants of the inhabitants, and a considerable amount has to be imported from the cantons of Bern and Basle. Potatoes are largely cultivated, even at great elevations among the mountains; and in the lower regions the cultivation of the vine is extensive, and the wines produced are highly esteemed. Of the whole surface of the canton, it has been calculated that about 42,700 acres are mountain pasture-land, 28,500 forests, 62,000 arable land, 37,000 meadows, and 2480 vineyards. The number of horned cattle in the canton in 1848 was 17,622; horses, 2589; sheep, 5113; goats, 2105; and swine, 4284. Bears and wolves, as well as deer and other kinds of game, are found in the forests; and the rivers and lakes abound in fish. The manufactures are of considerable importance; and among these that of watches occupies the first place, and has contributed most effectively to the prosperity of the country. This branch of industry was first introduced here in 1665; and after it had been a century in operation, 12,000 gold and silver watches were annually produced. In 1848 the canton contained 9067 watchmakers, by whom upwards of 100,000 watches were yearly produced. The chief seats of this manufacture were the villages of Locle and Chaux de Fonds, in the bleak uplands of the Jura. The manufacture of lace is also carried on to a considerable extent, but it has declined considerably from its former importance. There were in 1848 only 1475 hands employed in this branch of industry, of which the chief seat is in the Val de Travers. Manufactures of linen, cotton, paper, &c., are also carried on. The trade of Neuchâtel is not very extensive, and consists principally in the export of the various articles manufactured here. The established religion is Protestant and Calvinistic, and this is professed by the majority of the people, the proportion of Protestants to Roman Catholics being nearly twelve to one. There are also a small number of Jews. The constitution of the canton is very anomalous; for though the King of Prussia claims the title of Prince of Neuchâtel, he has resigned all right of sovereignty over it; and the constitution, as established April 30, 1848, is entirely republican. The legislative body consists of 80 members, chosen by the people, one for every 500 inhabitants. Their term of office is for six years, and one-third of the number go out every two years. The executive power is confided to a council of seven, chosen by the members of the legislature, and presiding each over one of the seven departments of the canton. Neuchâtel sends four members to the National Council of Switzerland, and two members to the Council of States. The canton of Neuchâtel was formerly a part of the German empire, but afterwards was bestowed on the House of Châlons, with the title of Count of Neuchâtel. These counts were subject to the feudal rights of the princes of Orange. In 1398 Neuchâtel was admitted into the Swiss Confederation; and in 1579 the county of Valendis having been joined to that of Neuchâtel, the title of Count was exchanged for that of Prince of Neuchâtel. The line of Châlons having become extinct, it passed to William III. of Great Britain as Prince of Orange; and on his death in 1702, his nephew Frederic I. of Prussia took possession of the principality. In 1805 it was ceded by the treaty of Tilsit to France, and given by Napoleon to Marshal Berthier; but it was restored to Prussia in 1814, though still recognised as holding the twenty-first place in the Swiss confederacy. After this it continued under the government of Prussia, and a constitution was granted by Frederick William III.; but in 1848 this state of things came to an end; a republican constitution was established; and since that time the authority of the King of Prussia has been merely nominal. On the 2d of September 1856 an attempt was made by a party of royalists to re-establish the authority of the Prussian monarch in Neuchâtel; but this proved unsuccessful, and they were taken prisoners, and arraigned for high treason. The Prussian ambassador demanded that the prisoners should be released, and the rights of Prussia recognised. This demand was rejected by the Swiss government, and the King of Prussia refused to enter into any negotiations about the canton of Neuchâtel until the prisoners were released. At last it was settled by a treaty at Paris, May 26th 1857, that an amnesty thould be granted to the insurgents of Neuchâtel, and that the King of Prussia should resign all claim of sovereignty over the canton, reserving only the right to bear the title of Prince of Neuchâtel. Pop. (1850) 70,753.

NEUCHÂTEL, the capital of the above canton, stands at the mouth of the Seyon, partly on the level ground on the shore of the lake, and party on the slope of the

Neuchâtel. Jura Mountains. It is well built, and contains several handsome streets, some of which stand on the alluvial ground gained from the lake. The castle, which is situated on an eminence, is an ancient building of some size, and was formerly the residence of the princes of Neuchâtel, but is now occupied by the government offices. Near the castle stands the church, a Gothic edifice of the twelfth century, with some parts of still more ancient date. The town-hall, a handsome building in the Grecian style, stands in the lower part of the town. The town contains also a public school, with a museum of natural history, a ladies' school, and two hospitals. A considerable trade is carried on through Neuchâtel in the manufactures and agricultural produce of the canton. Pop. (1850) 7727.

Neuhoff.

NEUCHÂTEL, *Lake*, forms the S.E. boundary of the canton of the same name, and is about 24 miles in length by 4 in breadth. The surface is 1320 feet above the sea, and the greatest depth is 400 feet. It is fed by the Orbe from the S.W., by the rivers of Neuchâtel from the N.W., and by the Broye from Lake Morat; and it discharges its waters by the Thielle into the Lake of Bienne, and thence into the Aar. The scenery of the lake is fine, but inferior in grandeur to that of some of the other Swiss lakes. A considerable trade is carried on on this lake; and it is navigated by a steamer, which touches at the principal places on its banks.

NEUDORF (Hungarian, *Iglo*), a town of Hungary, county of Zips, in a beautiful plain on the Hernad, 5 miles S. by W. of Leutshau, and 136 N.E. of Pesth. It is well built, and has one principal street and square. The parish church is a fine building with a lofty tower. There are also a Protestant church, a high school, court-house, town-hall, theatre, and hospital. The manufacture of linen and paper, and the forging of iron, are carried on here; and iron and copper mines are worked, and flax cultivated, in the vicinity. Pop. 5900.

NEUHAUS, a town of Bohemia, circle of Tabor, stands on the Nezarka, 26 miles N.E. of Budweis. It has an old castle, now in ruins, a handsome parish church, five other churches, a Franciscan convent, town-hall, barracks, and theatre. Manufactures of linen, cotton, and woollen fabrics are carried on. Pop. 7604.

NEUHAUSEL, a market-town of Hungary, in the county of Neutra, on the river, and 22 miles S.S.E. of the town of that name. It was formerly a fortress of some importance; and has a church, a Franciscan monastery, two schools, and a town-hall. Some trade is carried on in corn, wine, and cattle. Pop. 6780.

NEUHOFF, Theodor, Baron von, a noted military adventurer, was descended from a noble Westphalian family, and was born at Metz toward the close of the seventeenth century. His father, an officer in the French service, died when he was still young, and left him exposed to the attacks of poverty and the freaks of fortune. He obtained a lieutenancy in the regiment of Alsace; but a habit of falling into debt, and of never getting out of it, did not suffer him to remain long at this post. He then shifted about from one country to another, trusting to his titles, address, and good luck for a livelihood. At length he seemed to have gained a permanent footing in Spain. The two famous statesmen Alberoni and Ripperda patronized him in succession; a colonel's commission was conferred upon him; and a lady of honour to the Spanish queen gave him her hand in marriage. But no sooner did the German fortune-hunter find that his wife's dowry fell far short of his expectations, than he seized upon her jewels, bade adieu to the land of his adoption, and escaped over the border into France. His plunder was soon squandered, and his favourite character of wandering impostor was resumed. For several years he continued to skulk from one European city to another, changing his name to suit his circumstances, and fleeing from old debts only to fall into new ones. At last fortune began to smile upon him once more. Happening, in the course of his wanderings, to meet some of those Corsican patriots who were then asserting their country's independence against the Genoese, he commenced, with his usual ready hypocrisy, to profess a deep interest in their cause, and to proffer his counsel. He advised them to elect some noble and influential personage for their king, who should lead their armies, form their government, and lay the foundation of their independence; and he hinted that he, a German baron, and a favourite with the princes of Europe, was a suitable object for their choice. The hint was taken; and the Corsicans agreed to support his ambitious scheme, on condition that he should furnish some substantial proof of his devotion to their cause. Neuhoff was immediately on foot, using all his arts and address to obtain assistance from several European courts for the patriotic Corsicans. His efforts were unsuccessful. He then posted to Africa, and by dint of enormous promises, received a ship-load of supplies and ammunition from the Dey of Tunis. With these he landed at Corsica in March 1736, and was received with enthusiasm by the islanders. The game of ambition thus successfully begun was now played out with consummate tact and dexterity. He kept up a show of possessing great wealth; added to his name the honourable titles of most of the courts in Christendom; feigned to be constantly receiving despatches from the principal powers of Europe and Africa; and at length declared himself a candidate for the crown, and obtained it in the following April. The same system of display which had raised the foreign adventurer to the throne was now found necessary to keep him there. Accordingly, he surrounded himself with 400 body-guards, distributed among his followers many brevets of nobility, instituted a new order of knighthood under the name of the Order of Deliverance, and asserted his sovereign power and majesty by hanging up three persons of high birth. But these arts, though successful at first, could not long defend the impostor against the disclosures of advancing time. The great promises he had held out of foreign assistance continued to be unfulfilled; rumours concerning his real character began to reach the island; and the failure of his attempt to take the town of Bastia from the Genoese proved his incapacity to vindicate the freedom of his new subjects. His popularity was waning fast when, at the end of a reign of eight months, he entrusted the government to a council of regency, and repaired to Europe to procure the reinforcements which he had promised. Here ended the reign of Theodore I. of Corsica. Happening, in his vain search for supplies, to repair to Amsterdam, he was pounced upon by some of his old creditors, and was cast into prison. When by mortgaging two of the Corsican towns to a Jewish merchant, he had received a large sum of money, and had been enabled in 1738 to release himself from prison, and to repair to Corsica with three merchant vessels and a frigate, he found that the island was entirely under the power of the French, the allies of the Genoese, and that the islanders were unable to receive him. Affairs were not more favourable, even after the French had departed in 1741. On presenting himself once more before his subjects in 1742, Neuhoff found that there was a strong faction of the Corsicans against him, and that the Genoese had set a price upon his head. He immediately abandoned his forlorn hopes, and fled to England. The reverses, however, of this poor puppet of fortune were not yet at an end. His Dutch creditors soon ferreted him out, and for seven years he lay in the King's Bench Prison. Through the interference of Horace Walpole, he obtained his release in 1756, under the act of insolvency, and was enabled to make an agreement with his creditors by mortgaging Corsica. But grief and poverty brought his life to a close in December of the same year.

Neuilly-sur-Seine || Neuss.

NEUILLY-SUR-SEINE, a town of France, department of Seine, on the right bank of that river, about 1½ mile N.W. of Paris, on the road to St Germain. Here are the ruins of the palace of Neuilly, which was a favourite residence of Louis Philippe, but which was destroyed in 1848. The park of Neuilly, which extends for some distance down the river, is a favourite holiday resort of the Parisians. The river is here crossed by a handsome bridge of five arches, each 120 feet wide. Manufactures of porcelain, starch, and chemical substances are carried on. Pop. 15,897.

NEUMARKT, a town of Prussia, in the government of Breslau, 16 miles W.N.W. of the town of that name. It has Protestant and Roman Catholic churches, and several courts of law. Manufactures of tobacco, tiles, woollen and linen stuffs, and paper, are carried on here; and there is a market for corn. Pop. 4320.

NEUMÜNSTER, a town of Denmark, in the duchy of Holstein, 17 miles S.S.W. of Kiel. It is large and well built, and has a church in the Italian style of architecture. The manufactures are considerable, consisting principally of cloth and metal buttons. Pop. 4700.

NEUSATZ (Hung. *Uj-Videk*), a town of Hungary, county of Bacs, on the left bank of the Danube, opposite to Peterwardein, and 46 miles N.W. of Belgrade. It is surrounded by walls; and has several Greek, Roman Catholic, and Armenian churches; a synagogue; and several schools. A considerable trade is carried on here, for which the position of the town on the Danube, and not far from the Drave, the Save, and the Theiss, gives it great advantages. The Danube is here crossed by a bridge of boats. Commercial intercourse is carried on through Neusatz between Vienna, Leipsic, &c., on the one hand, and Salonika and other Turkish ports on the other. Pop. 19,700.

NEUSIEDL, Lake of (Hung. *Fertö Tava*), a lake of Hungary, extends between the counties of Œdenburg and Weiselburg. It is about 23 miles in length and 7 in breadth, and varies from 9 to 13 feet in depth; area about 120 square miles. Its waters are not potable, from containing much sulphate of soda, with some muriate of soda and carbonate of soda. (See Bright's *Travels in Hungary*.) It is fed by the River Vulka. The principal towns on its shores are Rusth and Neusiedl.

NEUSOHL, or Beszterczebanya, a town of Hungary, capital of the county of Sohl, in the territory of Presburg, is situated on the right bank of the Gran, about 80 miles N. of Buda. It is pretty well built, and has wide streets, and a market-place near the centre. It contains the ruins of an old castle; several churches, one of which has a bell weighing upwards of 5 tons; an episcopal palace; Roman Catholic and Protestant schools; a theatre; court-house; and infirmary. Neusohl is situated in the middle of a mining district, whence copper, gold, silver, iron, &c., are obtained; and the annual produce of the mines of Herrengrund, which are at some distance from the town, amounts to 100 tons of copper and 400 lb. of silver. Neusohl contains one of the largest smelting houses in Hungary; and the manufacture of sword-blades, cloth, leather, paper, earthenware, sugar, &c., is carried on here. Pop. 6500; but including the suburbs, upwards of 10,000.

NEUSS, a town of Prussia, in the province of Düsseldorf, near the union of the Erft and the Rhine, 21 miles N.W. of Cologne. It is surrounded by walls, and protected by towers and ditches. The principal building is the church of St Quirinus, which was built in the thirteenth century, and exhibits a curious specimen of the transition from the round to the pointed style in architecture. The town has also two other churches, a synagogue, a school, a lunatic asylum, orphan's hospital, &c. Manufactures of cotton and woollen cloth are carried on here; and there is a considerable trade, especially in corn, for which Neuss is the principal market in Rhenish Prussia. This town, under the name of *Novesium*, was founded by the Romans under Drusus, and is frequently mentioned by Tacitus. Pop. 9567.

Neustadt || Neu-Strelitz.

NEUSTADT (Polish, *Prudnitz*), a town of Prussia, in the province of Silesia, on the Prudnitz, 29 miles S.W. of Oppeln, and 18 S.E. of Neisse. It is well built, and contains Roman Catholic and Protestant churches, a convent, synagogue, two hospitals, courts of law, and a penitentiary. The manufactures consist of cloth, leather, paper, tiles, &c. Pop. 6797.

Neustadt, or *Wiener-Neustadt*, a town of Austria, 26 miles S. of Vienna. It is built with some regularity, in the form of a square, and surrounded by fortifications. The streets are broad and well paved. The ancient castle, which is now used as a military academy for the education of officers for the Austrian army, is a square building with a tower; and in the chapel attached to it the Emperor Maximilian I. is buried. This academy, the only one of the kind in the empire, is attended by 468 pupils, who receive their appointments, some from the emperor, and some from the provincial estates. Many of the public buildings of Neustadt were destroyed by a dreadful fire in 1834, which laid nearly the whole of the town in ashes. There is here a Cistercian convent, which has a museum and a library of 20,000 volumes. The manufactures are considerable, consisting of silk and velvet cloth, paper, porcelain, &c.; and an active transit trade in wine, hardware, leather, sugar, &c., is carried on. Neustadt, which is as old as the twelfth century, has obtained, on account of its constant fidelity to the Austrian princes, the designation of "Ever Faithful." Pop. 12,346.

Neustadt-an-der-Haardt, a town of Bavaria, circle of Palatinate, on the Spirebach, 14 miles W. of Spires, and 16 E.S.E. of Kaiserslautern. The principal church is a building of the tenth century, and contains monuments of many of the electors and counts palatine. There are also to be seen here the remains of an old castle, to which the town probably owed its origin. Neustadt has a court of law, a school, and an hospital. Its manufactures are cloth, paper, chemical substances, gunpowder, &c. Some trade is carried on in wine and timber. Pop. 6088.

Neustadt-an-der-Orla, a town of Saxe-Weimar, capital of a circle of the same name, 24 miles S.E. of Weimar. It has an ancient castle, two churches, a savings-bank, and an hospital. Manufactures of cloth, leather, &c., are carried on; and there is some trade in books. Pop. 4250.

Neustadt-Eberswalde, a town of Prussia, in the province of Brandenburg, on the Schwartz, 28 miles N.E. of Berlin. It is surrounded by walls, and consists of three parts, an upper and lower town, and a suburb. It has mineral baths; and manufactures of hardware, cloth, earthenware, &c. There is some trade in manufactured goods, and also in wool and cattle. Pop. 5581.

NEUSTADTL-AN-DER-WAAG, or Vagh-Ujhely, a town of Hungary, county of Neutra, on the Waag, 52 miles N.N.E. of Presburg. The cultivation of the vine is largely carried on here; and there is a considerable trade in corn, wool, &c. Pop. 5500.

NEU-STRELITZ, the capital of the grand duchy of Mecklenburg-Strelitz, is situated on Lake Zierker, 57 miles N. of Berlin. It is regularly built, in the form of an octagon, has several handsome streets and squares, and is surrounded by walls and fortifications. The palace of the grand duke is a building partly in the Grecian, partly in the Italian style, and contains an extensive library and a collection of antiquities. In the town there are various churches, a college, several hospitals, schools, a theatre, &c. Most of the inhabitants find employment in connection with the court or the army; but some are engaged in the manufacture of beer, soap, tobacco, &c. Neu-Strelitz is the seat of the legislature and of the supreme courts of law, as well as of the government of the duchy. It was

Neutitschein || Neutrality.

founded by Adolph Frederic, who fixed upon this as his residence, after the destruction by fire, in 1712, of the former palace at Alt-Strelitz, some miles distant. The town thus rose up round the new palace; but the intention of their founder to connect by buildings the old and new towns has not been carried into effect. Pop. 6484.

NEUTITSCHEIN, or NOWY-GYCIN, a town of Austria, in Moravia, stands on the Titsch, 26 miles E. of Olmütz. It is well built; and has an old castle, three churches (one of which is ancient, and in the Byzantine style), a town-hall, and several schools and hospitals. The inhabitants are principally employed in the manufacture of woollen stuffs, in which some trade is carried on. Pop. 9000.

NEUTRA, or NYITRA, a town of Hungary, capital of a county of the same name, stands on the River Neutra, about 50 miles E.N.E. of Presburg, and 70 N.W. of Buda. It has a castle, which stands on an eminence, and contains within its precincts a cathedral, an episcopal palace, and a county-hall. Neutra has also a theological seminary, a high school, an inferior school, and a charity school belonging to the order of the Piarists. The inhabitants are chiefly employed in agriculture, but partly also in weaving; and an active trade is carried on in the wines of the adjacent country. Pop. 4490.

Definition.

NEUTRALITY (Fr. *Neutralité*), in politics is the term employed to indicate the state of those nations who, when a war is being carried on, take no part in the contest, and evince no peculiar friendship for, or hostility to, any of the belligerent powers.

Neutrality in general.

Many volumes have been written in regard to the rights and duties of neutral nations. But it is easy to see that these cannot be exactly defined; that, with the exception of a few leading principles, they are necessarily subject to much alteration; and that a line of conduct which a neutral power might very properly follow at one time and under one set of circumstances, might be very improper at another time and under a different set of circumstances. This arises from the fact, that the rights and duties of neutrals are not absolute, but relative only. They are in all cases affected by, and mixed up with, the rights of belligerents. And as the latter vary with the varying nature of different contests, so must the former, or the rights of neutrals.

In general it may be laid down that it is the duty of neutrals to conduct themselves in a spirit of perfect impartiality, and to do nothing that can be fairly considered as being peculiarly favourable or hostile to either of the parties engaged in hostilities. And this is about the only principle that can be said to be universally applicable to neutrals.

We do not mean, in the few remarks we have to offer on this subject, to enter into any inquiries with regard to the conduct of neutrals on land. The questions to which such conduct may give rise are for the most part easy of solution, and have comparatively little interest. But it is otherwise with those questions which arise out of the proceedings of neutrals at sea. These give birth to questions in regard to which there is much diversity of opinion; and which, from our being a great maritime power and their direct bearing on our interests, have always been justly looked upon in this country as of paramount importance.

Articles contraband of war.

I. When two nations are engaged in war, if there be any foreign article or articles necessary for the defence or subsistence of either of them, and without which it would be difficult for it to carry on the contest, the other may legitimately exert every means in its power to prevent its opponent being supplied with such article or articles. All writers of authority on international law admit this principle; and lay it down, that a nation which should furnish a belligerent with articles *contraband of war*—that is, with supplies of warlike stores, or of any article required for the prosecution of the war—would forfeit her neutral character, and that the other belligerent would be warranted in preventing such succours from being sent, and confiscating them as lawful prize. And besides being consistent with the most obvious principles, approved by jurists, and enforced in every contest, this doctrine has been sanctioned by repeated treaties. The only difficulty, indeed, that has ever arisen in regard to this matter has been with respect to the articles which should be reckoned contraband of war; and in the view of obviating such difficulty, these articles have sometimes been specified in treaties and conventions. (See the references in *Lampredi del Commercio de' Popoli Neutrali*, § 9.) But this classification has not always been respected during hostilities. And it is sufficiently evident that an article which may not be contraband at one time, or under certain circumstances, may become contraband at another time, or under different circumstances. It is admitted on all hands, even by Hubner, the great advocate for the freedom of neutral commerce,[1] that everything that may be made *directly available* for hostile purposes is contraband, as arms, ammunition, horses, timber for ship-building, and all sorts of naval stores. The greatest difficulty has occurred in deciding as to provisions (*munitions de bouche*), which have sometimes been held to be contraband, and sometimes not. Lord Stowell has shown that the *character of the port* to which the provisions are destined, is a principal circumstance to be attended to in deciding whether they are to be looked upon as contraband. A cargo of provisions intended for an enemy's port, in which it was known that a warlike armament was in preparation, would be liable to arrest and confiscation; while, if the same cargo were intended for a port where none but merchantmen were fitted out, the most that could be done, according to his lordship, would be to detain it, paying the neutral the same price for it he would have got from the enemy.

Neutrality.

By the ancient law of Europe, a ship conveying any contraband article was liable to confiscation as well as the article. But in the modern practice of the courts of admiralty of this and other countries, a milder rule has been adopted, and the carriage of contraband articles is attended only with the loss of freight and expenses, unless when the ship belongs to the owner of the contraband cargo, or when the simple misconduct of conveying such cargo has been connected with other malignant and aggravating circumstances. Of these, a false destination and false papers are justly held to be the worst.

It appears pretty evident that the principle on which the doctrine of goods contraband of war has been established may justify, or rather require, its extension to various important articles not hitherto or usually reckoned as contraband. The rights of belligerents to hinder neutrals from supplying their enemies with articles necessary to enable them to carry on the contest, is alike clear and undoubted. But a foreign article, indispensable or highly useful to a nation engaged in war, may not be of the class called *munitions de guerre*, and may not be directly available in the prosecution of hostilities. That, however, is really immaterial. It is enough to warrant the prevention of its importation, that without it the importers would be unable to continue the contest, or that the inconveniences resulting from the want of it would be so very considerable as to dispose them to sue for peace, or to accept reasonable terms if offered. The distinctive peculiarity of articles declared to be contraband of war is not that they belong to one class of products or another, but that the want of them would inflict serious injury on the party by whom they are imported.

Considered in this, its true light, the term "contraband of war" becomes of the highest importance; and there are

[1] *De la Saisie des Bâtimens Neutres*, tom. i., p. 193.

Neutrality. but few products which may not be fairly brought, at one period or another, within the list of contraband articles. Thus, supposing that we had the misfortune to be engaged in a contest either with a single power or a combination of powers which had means to intercept, cut off, or materially obstruct our supplies of corn, cotton, and tea: can any one doubt that our enemies would be justified, or that they would hesitate, in availing themselves of so powerful a means of annoyance? Neutrals might join us in protesting against such a proceeding, on the ground that the articles referred to had not hitherto been reckoned contraband of war, and they might also allege that their trade would be seriously prejudiced by so unusual and so illegal a proceeding. But these representations, supposing them to be made, would not go for much. Our enemies would say, that in defining contraband of war, everything depended on circumstances; and that as the want of the articles referred to would lay us under very considerable difficulties, they were, from that very circumstance, properly included in the prohibited list. They would no doubt express at the same time their regret that this conduct of theirs should be productive of injury or inconvenience to neutrals. That was not its purpose. They had resorted to it in the exercise of their undoubted rights as belligerents;[1] and it was only indirectly and by accident that it affected neutrals. When great nations are at war, such contingencies can seldom be avoided; and when they occur, they should be ascribed to the necessity of the case, and afford no reasonable ground of complaint.

Nations engaged in hostilities may not always have acted on these principles; but if so, it will be found that their forbearance was not dictated by a want of right or of will, but of power. Supposing that we were unhappily again engaged in a struggle with France, we could not employ our navy in any way more likely to accelerate the return of peace than in preventing the importation of cotton, colonial produce, and naval stores, into that country; and the exportation of her silks, wines, and other products. This would be a very likely way to distress our enemy; and the more he is distressed, the sooner will the struggle terminate.

In the following Declaration in regard to maritime law, signed by the principal European powers in 1856, the disputes to which its uncertainty has led are justly deplored:—

Declaration of 1856 in regard to maritime law.

"*Declaration respecting Maritime Law, signed by the Plenipotentiaries of Great Britain, Austria, France, Prussia, Russia, Sardinia, and Turkey, assembled in Congress at Paris, April* 16, 1856.

"The Plenipotentiaries who signed the Treaty of Paris of the 30th of March 1856, assembled in Conference,—

"Considering:

"That maritime law, in time of war, has long been the subject of deplorable disputes;

"That the uncertainty of the law, and of the duties in such a matter, gives rise to differences of opinion between neutrals and belligerents which may occasion serious difficulties, and even conflicts;

"That it is consequently advantageous to establish a uniform doctrine on so important a point;

"That the Plenipotentiaries assembled in Congress at Paris cannot better respond to the intentions by which their Governments are animated, than by seeking to introduce into international relations fixed principles in this respect; Neutrality.

"The above-mentioned Plenipotentiaries, being duly authorized, resolved to concert among themselves as to the means of attaining this object; and, having come to an agreement, have adopted the following solemn Declaration:—

"1. Privateering is, and remains, abolished;

"2. The neutral flag covers enemy's goods, with the exception of contraband of war;

"3. Neutral goods, with the exception of contraband of war, are not liable to capture under enemy's flag;

"4. Blockades, in order to be binding, must be effective, that is to say, maintained by a force sufficient really to prevent access to the coast of the enemy.

"The Governments of the undersigned Plenipotentiaries engage to bring the present Declaration to the knowledge of the States which have not taken part in the Congress of Paris, and to invite them to accede to it.

"Convinced that the maxims which they now proclaim cannot but be received with gratitude by the whole world, the undersigned Plenipotentiaries doubt not that the efforts of their Governments to obtain the general adoption thereof will be crowned with full success.

"The present Declaration is not and shall not be binding, except between those Powers who have acceded, or shall accede, to it.

"Done at Paris, the 16th April, 1856.

(Signed) "Buol-Schauenstein.
"Walewski.
"Clarendon, &c."

But the "uncertainty" complained of in the above Declaration is not of a kind that can be got rid of. It is inherent in the subject. Maritime laws of the class now under consideration do not rest on any fixed or immutable principles. They necessarily vary with the varying condition and exigencies of society. And those rules and regulations that may in the estimation of one country appear to be alike just and expedient, may in that of another be held, on quite as good grounds, to have exactly the opposite qualities. The above Declaration expressly excepts articles contraband of war from the privileges conceded to goods on board neutral ships; but it does not specify the articles which are to be considered contraband. And it was quite as well that this vexed, or rather insoluble question was left open; for it is most probable that the plenipotentiaries who subscribed the Declaration would not have agreed on any definition. And supposing they had subjoined a list of contraband articles to the Declaration, it would very speedily have ceased to be of any weight. Whether an article should or should not be deemed to be contraband depends on circumstances which it is impossible to foresee or appreciate beforehand. And such being the case, it is futile to attempt to prevent further disputes by making out lists of contraband articles. We have seen that this has been frequently attempted, and it has as frequently failed. Such lists may be respected for a while; but as soon as any contracting party or great power conceives that it would be for her interest or advantage to exclude some articles from, and to include others in, the list, there is an end of its influence and authority.

[1] Une puissance belligérante ne peut voir avec indifférence que son ennemi se renforce par des marchandises qui servent directement et indubitablement à faire la guerre; et elle ne blesse pas le droit des gens si elle empêche que ses marchandises ne parviennent à l'ennemi en les détenant, soit pour en payer la valeur au propriétaire, soit pour les restituer quand le danger sera passé. On peut même imaginer des cas, où les circonstances extraordinaires justifiéraient une telle detention à l'égard des marchandises, qui ne servent pas exclusivement à l'usage de la guerre, et sur lesquelles elle ne peut dans la règle s'arroger aucune disposition. (Martens, *Precis du Droit Public*, lib. viii., cap. 7, § 315.) Heineccius says, "Dans une guerre il ne s'agit pas même de demander s'il peut-être permis à quelqu'un de porter à notre ennemi ce qui peut lui être nécessaire puisque nous avons le droit de prendre les armes contre quiconque s'opposerait à notre defense ou la rendrait difficile ou incertaine." (Quoted by Lampredi, p. 47, Paris 1802· see also Vattel, book iii., cap. 7, § 113, and a host of other authorities.)

Neutrality.

The principle that free ships make free goods, or that the flag covers the cargo (*que le pavillon couvre la marchandise*), and that consequently enemies' goods, not contraband of war, may be safely conveyed in neutral bottoms, after being long resisted by this and most other maritime states, has been assented to in the Declaration referred to. In judging of the wisdom of this concession, everything depends on the interpretation of the phrase "contraband of war." If it were restricted, as has usually been the case, to warlike stores (*munitions de guerre*), or articles directly available for warlike purposes, it would be in many respects justly censurable. For it is plain, that under the limitation now supposed, the trade of a belligerent power, with its colonies or other countries beyond sea, might be prosecuted in neutral ships nearly to the same extent, and with as much security, during war as during peace. But it is not easy to imagine that a principle having such consequences should be acted upon by any power having a preponderating naval force, in the event of her engaging in hostilities. Such power must then do one of two things: she must either consent to relinquish some of the most important advantages to be derived from her naval ascendancy, or she must reject the principle in question. And there is little doubt that she would adopt the latter alternative; and she might do this directly, by resorting to her natural and indefeasible right to seize enemies' goods wherever they are to be met with; or indirectly, by extending the list of contraband articles, so as to make it include all those of any importance carried by sea into or from the enemy's ports. Either way would answer the purpose; and we may be pretty well assured, that under the supposed circumstances one or other of them would be followed.

Blockade, influence of.

II. But it may perhaps be said, that though the right to carry enemies' goods not contraband of war be conceded to neutrals by the Declaration of Paris, that right is restricted and confined within proper limits by the maintenance of the system of blockade. But we take leave to doubt whether this restriction be good for much. It is distinctly laid down in the Declaration, that to be binding or legal, a blockade must be effective; that is, it must be "maintained by a force sufficient really to prevent access to the coast of the enemy." But though the blockade of one or of a few ports may perhaps be made effective, it is abundantly certain that no such blockade can ever be made to apply to an extensive coast. Though our navy were doubled or trebled, it would not suffice to make an effective blockade of the coasts of France, of Spain, or of the United States. And why should a country with a powerful naval force bind herself beforehand to employ it only in one way? Why not employ it in any way, whatever it may be, which happens to be at the time most conducive to the ends she has in view?

But supposing that an impossibility may be realized, or that an extensive coast may be effectually blockaded, the circumstance would be of much less consequence now than formerly, or than is generally imagined. Suppose, for example, that we are at war with France, and that we effectively blockade every portion of her coast, whether on the ocean or the Mediterranean: the result would be, that the over-sea produce suitable to her wants would be imported into the contiguous ports of Belgium, Spain, and Piedmont, and that it would be carried from them by railways and otherwise to every part of France.

It is plain, therefore, that these are not matters in which much dependence can be placed on the resource of blockades. These may be advantageously resorted to when the object is to reduce a town, to obstruct the trade of a port or a river, to prevent the sailing of a squadron, and so forth; but as measures directed against the trade of any great country, they must be nearly, if not wholly, impotent. In the case of France, it is quite clear that the strictest possible blockade could not inflict half the injury on her that its maintenance would entail upon ourselves. If the trade of neutrals in war is to be influenced by nothing but effective blockades, it may be held to be practically free from all obstruction. But it cannot be supposed that when the evil day comes it will be so dealt with. When the existence of nations are at stake, they will not be withheld by declarations like the above from availing themselves of every means by which they may hope either to promote their own security or to injure their enemies.

Neutrality.

Influence of the new system over the trade of belligerents.

III. It is further obvious, were the rules laid down in the Declaration of 1856 to be carried into effect without large additions being made to the list of contraband articles, that neutrals would engross almost the entire over-sea trade of countries engaged in war. Comparatively few of the articles which we export come under the description of warlike stores; and supposing we were to be engaged in hostilities, neutral ships which did not take on board contraband articles would navigate with perfect security, while our ships would be exposed to the risk of capture. The magnitude of this risk would depend on various contingencies, and would be measured by the higher premium of insurance that would have to be paid on them and on articles embarked in them. But considering the close competition to which our shipowners are already exposed, the additional premium they would have to pay, even though it were not very considerable, would most probably turn the scale in favour of the neutrals; and if they were once introduced and employed for any considerable period, it might not be an easy matter for our ship-owners to regain the ground they had lost, or to recover their former position, on hostilities being terminated. But in whatever way it may be defeated or eluded, it is not to be supposed that we should abide, in periods of war and difficulty, by a rule that would tie up our hands and consign the entire over-sea trade of the empire to foreigners. This would be a degree of liberality to which we can hardly be expected ever to arrive, and which, were it realized, would be more injurious to our best interests than the most intense selfishness.

Project for exempting private property at sea from attack during war. Inexpediency of such project.

IV. Some of the more recent opponents of the old system of maritime law do not deny these statements. But they allege that they are founded on false principles. Private property, say they, is now respected in all contests carried on by land; and it would be for the advantage of all nations, whether belligerent or neutral, were the same humane and generous policy extended to private property at sea. But this sort of reasoning is more specious than solid. On a little examination it will be found that the cases have no real analogy. Private property on land, and the treasures of art and learning, are respected so far, that they are sometimes unconditionally, but frequently also on the payment of a contribution or ransom, exempted from injury. This is done because experience has shown that, while the destruction of the articles referred to may be productive of much misery and loss, it has little or no influence over the decision of the contest. But we are not hence to infer that the destruction of private property at sea will be equally ineffectual. In our unfortunate contest with the United States in 1814, the destruction of the Capitol at Washington was an act disgraceful to our arms, and which had no effect except to inflame the hostile feelings of the Americans. But the severe check which the contest gave to the trade of the Union made the citizens generally averse to the war; and was, indeed, the main cause of its being so speedily terminated. No such result could, however, have happened had American merchant ships been exempted from capture or molestation.

Suppose we are at war, and that our enemy, having succeeded in landing a force in some part of the kingdom, such as Kent or Connaught, inflicts on the peasantry out-

Neutrality. rages similar to those which the troops of Louis XIV. inflicted on the defenceless inhabitants of the Palatinate; such proceedings, by not sensibly affecting either our wealth or the sources of our power, would in no wise accelerate the termination of hostilities. On the contrary, they would tend to their prolongation, by inspiring us with a strong desire to avenge such wanton and unnecessary cruelty. But it would be quite another matter were our enemy able seriously to obstruct our trade, to prevent our exports, or to sink, burn and destroy the ships that were conveying to us supplies of necessary articles. Such proceedings might lay us under the greatest difficulties, and would be the most likely means to make us listen to proposals for an accommodation.

Everybody knows that the unpopularity of the French rule in Germany and other parts of the Continent, in the latter part of the war against Napoleon, was in great measure occasioned by the destruction of their trade, which, on the one hand, rendered their corn and other disposable produce a mere drug, while, on the other, it added enormously to the prices of cotton, sugar, coffee, and most foreign articles. But had the rules and regulations embodied in the Declaration of 1856 been then in force, no such result would have happened. We should have had the singular combination of maritime peace and territorial war. And the trade of Prussia, Holland, and the other countries subject to France, and, indeed, of France herself, would have been as securely and cheaply carried on in neutral bottoms as it would have been in a period of universal tranquillity. Nothing, therefore, can be more contradictory and illogical than to contend that we are bound to extend the same immunity during war to private property at sea that is extended to private property on land. The cases are in no degree parallel. In the one, private property is respected because its destruction is seldom injurious except to the individuals immediately interested, and has little or no general influence; in the other case, private property is seized or destroyed because those from whom it is taken, being the carriers or purveyors of necessary articles for the community, their loss must seriously affect the latter, and may reduce them to the greatest straits.

Abolition of privateering.

V. The abolition of privateering by the Declaration of Paris is of the highest importance, and should give general satisfaction. This practice appears to be a remnant of that system of private war which is universally waged by individuals in early or barbarous ages, but which gradually disappears as society advances. Privateers rarely attack ships of war. They do not act in concert, or with any object in view other than their own private gains. They are, in truth, a sort of legalized robbers;[1] and while they occasion much individual suffering, they have little or no influence over the result of the war. But their employment is principally objectionable from its having been found that, despite every precaution, it is not possible to hinder them from committing the greatest excesses. The desire to amass plunder is the ruling passion by which they are actuated; and being so, it would be childish to suppose that they should be scrupulous in their proceedings, or that they should endeavour to keep within the pale of the law when they think that their objects will be likely to be promoted by overstepping its limits. And hence their injurious treatment of the ships of neutral and friendly powers. A system of this sort may perhaps be useful to a nation which has little trade, and may hope to acquire riches by fitting out privateers, without being exposed to the risk of retaliation. But except under very peculiar circumstances, it is difficult to suppose that it should be advantageous to a nation with an extensive over-sea trade. A notion has, indeed, been long entertained, that while the interests of humanity would be promoted, the rights of belligerents would not be injuriously affected by the abolition of privateering. It was stipulated, for instance, in the treaty between Sweden and the United Provinces in 1675, that neither party should in any future war grant letters of marque against the other; and stipulations to the like effect have since been embodied in various treaties. These, however, being only isolated efforts, were insufficient materially to abate the nuisance, which could not be put down without an agreement to that effect by the great powers, such as has been announced in the Declaration of 1856. Neutrality.

The United States, however, though possessed of a most extensive mercantile marine, have refused to consent to the abolition of privateering. But they have not done this capriciously; nor is it to be denied that there is a great deal of weight in the reasons given by the American government for their refusal.[2] They grow out of circumstances peculiar to the United States,—that is, of their warlike navy bearing but a very small proportion to their mercantile navy, which is the largest in the world. And they contend, that were they to abolish privateering, their merchant ships would be captured in vast numbers by the numerous cruisers of their enemies; while the merchant ships of the latter, owing to the fewness of their own ships of war, would be comparatively little affected; and that to restore the balance, to place themselves on a level with their opponents, they have no resource but to appeal to the patriotism (selfishness) of their citizens by licensing privateers.

The Americans have, however, intimated their willingness to assent to the abolition of privateering, provided the other powers agree not to attack or molest private ships at sea during war. Such an agreement would no doubt be very much for their advantage; but we have already seen that it is not one to which we can consent without at the same time, and by the same act, consenting to forego the use of some of the most powerful of our means of defence and attack. This, however, is about the very last thing that we either should or will do. No British statesman will ever agree to an arrangement that would diminish our powers and paralyze our energies at the very moment when, perhaps, our independence and security may depend on these being exerted to the utmost.

Right of search.

VI. Nothing is said in the Declaration of 1856 in regard to the right of visitation and search, probably because it is obviously inherent in belligerents; for it would be absurd to allow that they had a right to prevent the conveyance of contraband goods to an enemy, and to deny them the use of the only means by which such right can be made available. The object of the search is twofold: *first*, to ascertain whether the ship is neutral or an enemy, for everybody knows that the circumstance of its hoisting a neutral flag affords no security that it is really such; and, *secondly*, to ascertain whether it has contraband articles or enemies' property on board. All neutral ships that would navigate securely during war must consequently heave-to when summoned by the cruisers of either belligerent, and be provided with passports from their government, and with all the papers or documents necessary to prove the property of the ship and cargo; and they must carefully avoid taking any contraband articles, and perhaps also belligerent property, on board. And hence it has been generally admitted that a merchant ship which seeks to avoid a search by crowding sail or by open force, may be justly captured and confiscated.

[1] L'armateur indifferent au sort de la guerre et souvent de sa patrie, n'a d'autre amorce que l'avidité du gain, d'autre recompense que ses prises et les prix attachés par l'état à ses pirateries privilegiées. (Martens, *Essai sur les Armateurs*, cap. i., § 8.) This essay, which was translated into English, and published in 1801, contains the fullest details in regard to privateering. Valin, who defends and even eulogizes privateering, admits that it is very apt *dégénérer en abus et en brigandage*. (*Traité des Prises*, i., cap. i., § 7.)

[2] See Letters of Mr Marcy to the Count de Sartiges, 28th July 1856.

Neuwied.

One of the most difficult questions in regard to the right of search has reference to merchantmen sailing under convoy. Is the allegation of the officer commanding the vessel of war convoying the merchantmen, that the latter have no contraband articles or belligerent property on board, to be held to be sufficient to nullify the right of search? or may the exercise of that right be notwithstanding insisted upon?

A case of this sort occurred in the early part of 1798, when a fleet of merchantmen belonging to Sweden, a neutral power, and sailing under convoy of a frigate, were detained by a British squadron. The Swedish captain, on the question being put to him, answered that the ships were destined for different ports of the Mediterranean, and that they were laden with hemp, iron, pitch, and tar. These articles were the produce of Sweden;[1] but as they have most commonly been reckoned contraband of war, and as France and her allies had many ports on the Mediterranean, there can be little or no doubt that we were warranted, despite the threatened but unattempted opposition of the Swedish captain, in detaining the ships. But besides being detained, they were condemned with their cargo as lawful prize; a proceeding which gave rise to a great deal of discussion at the time, and which it is not easy to justify.[2]

In the event of the captain of a vessel convoying neutral merchantmen distinctly declaring that they have no contraband articles or enemy's property on board, their detention or search would be a very strong measure. It would, in truth, be an insult to the flag and honour of the neutral power. And unless the presumptions that the captain had emitted a false declaration were exceedingly strong, to question his veracity would be an act contrary to the comity of nations, and one that a high-spirited people would be sure to resent. But except in the case of a limited number of vessels sailing to specified ports under convoy, and when there is a clear and explicit declaration by the officer in command that they have neither contraband articles nor belligerent property on board, the right of search, supposing it to be exercised without any unnecessary violence, is one that is essential to belligerents, and cannot be justly objected to. (J. R. M.)

NEUWIED, a town of Prussia, government of Coblentz, on the right bank of the Rhine, here crossed by a suspension-bridge, 7 miles N.N.W. of Coblentz. It is regularly built, in the form of a square; and the streets, which are broad and straight, intersect one another at right angles. At the west end, near the Rhine, stands the palace of the Prince of Wied, a fine building surrounded by gardens, and containing an extensive library and collections of Roman antiquities and of natural history; the latter of which was made by Prince Maximilian of Wied in North America and Brazil. Neuwied has one Roman Catholic and three Protestant churches, a synagogue, several schools, infirmaries, &c. The manufactures of the place are considerable, and consist of silk, cotton, wool, leather, hats, carpets, tobacco, chicory, hardware, beer, brandy, vinegar, &c. A large trade is carried on in manufactured articles, and also in pipe-clay, timber, iron, lead, corn, wine, and other products of the neighbouring country. The town was founded in the first half of the eighteenth century, upon the principle of affording complete toleration to every religious sect; and it rapidly rose to a flourishing condition, being peopled by Protestants, Roman Catholics, Jews, Moravians, &c. The principality of Wied was for a long time independent, but was annexed to Prussia in 1814. Pop. 6659.

Neva || Nevers.

NEVA, a river of Russia, flows from Lake Ladoga to the Baltic, into which it discharges itself by several mouths at St Petersburg, after a course of about 40 miles. It forms the only outlet of the four lakes of Onega, Ilmen, Saima, and Ladoga; and owing to the vast extent of these sheets of water, that of Ladoga being the largest in Europe, it conveys an immense quantity of water to the sea. Its average breadth is 1500 feet, its depth about 50 feet; and, flowing with a velocity of 37 inches per second, it has been calculated to carry to the Gulf of Finland 116,000 cubic feet of water in a second. Such a body of water, moving at such a rate, would be exempt from the influences of frost, were it not for the long continuance of the winter, and the quantities of ice which are drifted down from the lakes by the violent storms to which they are subject. Owing to the combination of these circumstances, the river is generally frozen for four or five months in the year. The following are the dates of the opening and closing of the river by ice for each year from 1851 to 1856:—

Year.	Opening.	Closing.	Duration of Freezing.
1851.....	April 18th	December 4th	138 days.
1852.....	May 10th	October 29th	
1853.....	April 28th	November 30th	181 „
1854.....	April 26th	November 21st	147 „
1855.....	April 19th	November 23d	149 „
1856.....	April 30th	November 10th	159 „

NEVADA SIERRA. See Spain.

NEVERS, a town of France, capital of the department of Nièvre, stands on the right bank of the Loire, at its confluence with the Nièvre, 153 miles S.S.E. of Paris. It is built on the slope of a hill, and has a fine appearance when seen from the opposite side of the river; but the streets are narrow, steep, irregular, and dirty. Of the walls and towers that formerly defended the town some remains are still to be seen, and one of the old gates, called the Porte du Croux, still remains. The cathedral, a building of the thirteenth, fourteenth, and fifteenth centuries, stands at the top of the hill. It has a heavy appearance outside, but the interior is richly carved; and the choir contains some fine painted glass and old tapestry. The Romanesque church of St Stephen, built in 1063, is the oldest in Nevers. There are two other old churches, one of which is now used as a warehouse, and the other as a brewery. The former palace of the dukes of Nevers is now the town-hall, and the park behind it has been converted into a public garden. The town is entered from Paris by a triumphal arch, erected to commemorate the victory of the French at Fontenoy in 1745. Nevers also contains an arsenal, barracks, a college, several schools, a public library, and a society of agriculture, science, and art. It is the seat of a prefecture, of a bishopric, of a court of first resort, and of a court of commerce. The manufactures of Nevers are very considerable; that of pottery has been carried on here for eight centuries, and employs about 700 hands. Cannon and shot, chain-cables, anchors, massive machinery, implements of husbandry, violin-strings, glue, candles, beer, vinegar, ropes, and other articles are also made here. The trade of the place is also considerable; and there is a good harbour here on the river.

[1] Articles which form a considerable part of the produce of a country, though contraband of war, have sometimes been allowed to be conveyed in neutral ships. But even in that case belligerents have been accustomed to detain them, not for confiscation, but for pre-emption. (Robinson's *Admiralty Reports*, i. 244.)

[2] For an account of this famous case, see Robinson's *Admiralty Reports*, i., pp. 340–379. In an elaborate argument, Sir William Scott (afterwards Lord Stowell) states, with his usual ability, but with too sensible a bias, the reasons for his judgment. Its legality was questioned in a tract by Mr J. F. W. Schlegel, professor at Copenhagen, translated into English, and published in London in 1801. Schlegel was answered by Dr Croke in a tract entitled *Remarks on Mr Schlegel's Work on the Visitation of Neutral Vessels under Convoy.*

Nevin ‖ Nevis.

Timber, iron, steel, coal, wool, leather, wine, cattle, and manufactured goods form the chief articles of commerce. The town is ancient, and is mentioned by Cæsar, under the name of *Noviodunum*. Here that general, in 52 B.C., fixed his head-quarters, and here he left his hostages, supplies, baggage, and military chest. After his defeat at Gergovia, the people of Noviodunum rose against the Romans, massacred all of them who were in the town, and plundered the stores. The place was afterwards called *Nevirnum*, whence the modern name is derived. It was formerly the capital of a county, which was raised by Francis I. to the rank of a duchy. It was united to the crown of France by Charles III. of Gonzaga, the last duke, who sold the duchy in 1665 to Cardinal Mazarin. It then formed the province of Nivernais. Pop. (1856) 16,082.

NEVIN, or NEFN, a town of Wales, Carnarvonshire, on the shore of Carnarvon Bay, 20 miles S.S.W. of the town of Carnarvon. The town is ill built. It has a parish church, several chapels, and a number of schools. Some trade is carried on by steam navigation with Liverpool in agricultural produce. Edward I. held a festival and tournament here, soon after his conquest of Wales; and the position of the lists can still be traced. Pop. (1851) 1854.

NEVIS, one of the Leeward Islands, in the West Indies, is situated in N. Lat. 17. 10., W. Long. 62. 42. It has an area of about 20 square miles; and consists of a single conical mountain, rising to the height of 2500 feet above the sea, and surrounded by a tract of flat, fertile, and well-cultivated land. Nevis is well watered by streams and rivulets. It was formerly thickly wooded, and even now timber is plentiful on the island, especially on the higher parts of the mountain. The surface, from the shore to a considerable height, is occupied by sugar plantations; and though the soil of the higher districts is less fertile, the climate is not so warm, and many European vegetables are successfully cultivated. The island has no harbours, but there are three roadsteads, the best of which is that of Charlestown, the capital, which stands on the shore of a large bay. Nevis contained in 1850, 380 horses, 2110 horned cattle, 1605 sheep, and 351 mules. Sugar, molasses, and rum are the chief articles of produce; and these, along with live stock, furnish the principal exports of the island. The value of the exports in 1854 was L.32,794, and of imports in the same year L.20,933. Beef, pork, meal, flour, and cotton and linen stuffs are the principal articles imported. The number of vessels that entered in 1854 was 86, and their tonnage 4921; of those that cleared 85, and their tonnage 4518. The government is in the hands of a president, who is subject to the governor-in-chief of Antigua; and there is a council of seven, and a representative assembly of nine members. For ecclesiastical purposes, the island is divided into five parishes; and there is a Wesleyan mission, which has been in operation here since 1789. There were in 1854 fourteen schools, attended by 1707 scholars; but though the state of education is thus far satisfactory, the instruction is of a somewhat superficial and unpractical character. No government aid is given to the schools. There is an hospital on the island for the poor and infirm, which receives an annual grant of L.150. The revenue in 1854 amounted to L.3875, and the expenditure to L.4123.

This island was discovered by Columbus, and named by him after the mountain Nieves in Spain, to which it bore some resemblance. It was first settled by the British in 1628 from the neighbouring island of St Kitt's, and soon rose to a high pitch of prosperity and importance; but in the end of the seventeenth and beginning of the eighteenth century it suffered severely from the ravages of an epidemic, the hostilities of the French, and the devastation of a hurricane. Nevis afterwards gradually regained its prosperity; but since the emancipation of the slaves it has been gradually declining; the proprietors, from their aversion to that measure, having endeavoured to preserve as much as possible of the old system, which had ceased to be applicable or beneficial in the present state of society, instead of adopting a system suitable to the changed state of affairs. The absence of any law respecting the relations of master and servant produces mutual distrust; and the acquisition of wealth by the Negroes is still discouraged by their employers. The white population does not exceed 60 adult males; while the whole population is estimated at more than 10,000.

Nevyle ‖ Newark-upon-Trent

NEVYLE, or NEVILE, ALEXANDER, an old English author, was born in Kent in 1544. He is best known by an elegant and spirited metrical version, or rather paraphrase, of Seneca's *Œdipus*. It was written as early as his sixteenth year; and was printed in 1581 in a collection entitled *Seneca his Tenne Tragedies translated into English*. Nevyle is also known as the secretary to the famous Parker, Archbishop of Canterbury, and as the author of a Latin narrative of Kett's Norfolk insurrection, printed in 1575; and the Cambridge verses on the death of Sir Philip Sidney printed in 1587. His death took place in 1614.

NEW ALBANY, a town of the United States, North America, Indiana, is situated on the right bank of the Ohio, 3 miles below Louisville, and about 100 S. by E. of Indianapolis. It is one of the largest and most commercial places in the state; and has broad and handsome streets regularly laid out. There are about twelve churches, several schools, a theological seminary, a court-house, and a jail. Two newspapers are published here. Ship-building, especially that of steamers, is carried on here; and there are also machine-works, flour-mills, saw-mills, &c. It forms the southern terminus of the New Albany and Salem Railway, which extends as far N. as Michigan city. Pop. (1850) 8181; (1853) about 12,000.

NEWARK, a town of the United States of North America, state of New Jersey, is situated on the Passaic, 4 miles from its mouth, and 9 miles W. of New York. It is regularly laid out, with broad and straight streets intersecting each other at right angles; and has two spacious public squares, which are planted with fine elm trees. The court-house is a large structure of brown stone in the Egyptian style. The library building is also very handsome, and contains a public hall and a gallery of paintings. There are many fine churches in the town, three of which have elegant and lofty spires. They belong to Roman Catholics, Methodists, and Presbyterians. There are in all about forty churches of various sects in Newark. Among the literary and educational institutions are,—a historical society, a literary association, a Wesleyan institute, and seven schools, attended by about 2500 scholars. The chief importance of the town is derived from its extensive manufactures, of which the establishments for the production of India-rubber goods, of carriages, and of machinery are the largest and most important. Leather goods and articles of clothing are also manufactured. The trade of the city is principally coasting. The registered and enrolled shipping in 1852 had a tonnage of 5107, of which 1189 were propelled by steam. In the same year the number of ships that entered was 21, and their tonnage 2304; of those that cleared 13, tonnage 1393. Pop. (1850) 38,893; (1853) about 45,500.

NEWARK-UPON-TRENT, a market-town, and municipal and parliamentary borough of England, county of Nottingham, on an affluent of the Trent, 20 miles N.E. of Nottingham, and 124 N.N.W. of London. It is well though irregularly built, and has a large market-place in the centre. The parish church is one of the largest and finest in England; and though originally a Norman building, it underwent great changes in the time of Henry VI. It is in the form of a cross, has a lofty spire, and contains some fine painted glass, carved wood-work, and ancient monuments. To the N.W. of the town are the remains of an ancient castle, which was either built or repaired by Bishop Alex-

New Bedford || New Brunswick.

ander in 1125. King John died here in 1216; Wolsey lodged here after his fall in 1530; and in the neighbourhood Charles I. surrendered himself to the Scotch commissioners in 1646. Newark has Wesleyan Methodist, Baptist, Independent, and other chapels; a town-hall, court-house, several schools, and almshouses. A considerable trade is carried on in malt, flour, corn, wool, cattle, and coal; and the commerce of the river is facilitated by the wharves and warehouses which have been constructed here. A county court is held at Newark; and there are six annual cattle fairs. The borough returns two members to the House of Commons. Pop. (1851) 11,330.

NEW BEDFORD, a town of the United States of North America, in the state of Massachusetts, is situated on the estuary of the Acushnet, an arm of Buzzard's Bay, 55 miles S. of Boston. It stands on the slope of a hill, and is for the most part built of wood. The streets, which are straight and regular, are generally lined with trees, and many of the houses are surrounded by gardens. The town-hall is a very handsome building of granite, 100 feet long, 60 wide, and three storeys high. There is also a fine granite custom-house. New Bedford contains about 20 places of worship belonging to various denominations, and numerous public schools. The manufactures are considerable, but principally in connection with the whaling trade, in which the town is extensively engaged. Ship-building and coopering are largely carried on. In the year ending June 30, 1852, 18 vessels were admeasured, having a tonnage of 5626. There are more than twenty manufactories of oil of various kinds, and several planing-mills, rope-works, iron-works, &c. The shipping of New Bedford is chiefly employed in whaling; and the total amount registered and enrolled had in 1852 a tonnage of 149,208, of which 125,530 tons were employed in the whale fishery. The number of ships that entered in that year was 113, with a tonnage of 27,940; those that cleared 174, with a tonnage of 55,347. Pop. (1850) 16,443; (1853) about 17,500.

NEWBERN, a town of the United States of North America, in North Carolina, stands at the confluence of the rivers Neuse and Trent, 120 miles S.E. of Raleigh. It was formerly for some time the capital of the state. It has a court-house, jail, theatre, public hall, and several churches and schools. The trade of the place is considerable, and the river is navigable for steamers for eight months in the year. Grain, timber, turpentine, tar, and naval stores are exported. The registered and enrolled tonnage of the port in 1852 was 5235. The vessels that arrived in the same year were 22, tonnage 2822; those that cleared 24, tonnage 3151. Pop. (1850) 4722.

NEW BRITAIN, an island in the Pacific Ocean, N.E. of New Guinea, between S. Lat. 5. and 7. 30., and E. Long. 148. and 153. It is separated from New Guinea by Dampier's Strait, which is about 40 miles broad, and from New Ireland by St George's Channel. The outline is irregular, and the area is 24,000 square miles. The surface is mountainous, rising to a considerable height, and well wooded on the sloping sides. In some places the mountains extend quite to the coast; but in others there are extensive plains stretching along the shore. The highest summit in the island has been observed to emit smoke. The soil is fertile, and produces bananas, bread-fruit trees, sago palms, cocoa-nut palms, and other trees; besides sugar-canes, bamboos, yams, ginger, &c. The animal kingdom is represented by dogs, pigs, turtle, and fish in large numbers. The New Britons resemble the Papuans in their stout, well-proportioned figures and dark complexions. They are numerous and entirely uncivilized, without any articles of clothing.

NEW BRUNSWICK, a colony of Great Britain in North America, lying between N. Lat. 45. and 48. 5., W. Long. 63. 50. and 67. 53.; and bounded on the N. by the it from Lower Canada; E. by the Gulf of St Lawrence; S. by Nova Scotia and the Bay of Fundy; and W. by the state of Maine. Its length from N. to S. is 180 miles; breadth, 150; area, 27,704 square miles. Its form is that of an irregular quadrangle, and the length of its coast-line is about 500 miles.

New Brunswick

The surface of New Brunswick, though not presenting very striking varieties in the character of the different parts, may be divided into three regions, differing to some extent from each other in nature and aspect. The southern region comprises the tract of land which stretches along the Bay of Fundy, and is divided into two unequal parts by the River St John. The whole coast of this region is bold and rocky, and the surface is much broken and diversified with rocks and ravines. To the W. of the St John the soil is deep and fertile, and covered with tall and dense forests. To the E. of that river the soil is not so fertile, but there are many beautiful valleys covered with forests mixed with corn-fields, and traversed by streams flowing into lakes at the bottom of the valleys, and ultimately joining the St John. The coast of the central region, along the Gulf of St Lawrence, is low and sandy, covered with trees of a small size. For nearly 20 miles inland the country is flat, and consists of marshes and mosses; but in the interior it rises into gently-sloping hills and undulations, which extend westward as far as the St John. The northern and north-western parts of New Brunswick are more mountainous than any of the other regions. A branch of the Alleghany Mountains traverses the N.W. corner of the province, from the borders of Maine to the Bay of Chaleurs. The mountains are not of any great height; and while some are bold and precipitous towards the top, others are of a more rounded form, and many of the hills are clothed with wood to their summits. The scenery of this district is exceedingly varied and beautiful; the mountains and glens contrast finely with the rich valleys, the rivers, cataracts, and lakes, that are everywhere seen; and the immense forests add to the beauty and luxuriance of the view. It is these forests that form the most striking feature of New Brunswick, and constitute not the least part of its value to the colonist. The principal trees are those belonging to the order of pines, which occupy most of the low-lying land in the province. Pines, larches, and spruces occur in great abundance; and the rocky shores of the Bay of Fundy are rendered extremely picturesque, especially in winter, by the dark-green clumps of spruces contrasting finely with the snow which lies around, and standing firm against the winds and storms which agitate the waves beneath. The oak, ash, maple, birch, poplar, and many other trees, are also found in New Brunswick, affording inexhaustible supplies of timber, and giving the forests in autumn a most gorgeous and rich appearance from the varied tints of their foliage and flowers.

Surface.

A circumstance that adds greatly to the resources of the country and the beauty of the scenery, is the number of rivers, streams, and lakes with which it is watered. Hardly any part of the country is destitute of some stream, of greater or less size; and in some parts of the interior a canoe can be conveyed with equal ease to the Bay of Chaleurs, the Gulf of St Lawrence, or the Bay of Fundy. The largest river is the Looshtook or St John, which rises in a lake of the same name in the state of Maine, flows first N.E. and afterwards E., forming part of the boundary between Maine and Canada. It then enters New Brunswick, and flows S. and S.E., till it falls into the Bay of Fundy at St John's, after a course of 450 miles. About 225 miles above its mouth, where the river enters New Brunswick, occur the Grand Falls, a cataract 58 feet in height, over which the rocks rise steeply to the height of 100 or 150 feet. The St John is navigable for large

Rivers and lakes.

New Brunswick.

smaller vessels can ascend to the falls. Above them it is navigated by steamers for 40 miles, to the mouth of the Madawaska; and small boats and canoes may proceed as far as the source. The St John receives many tributaries, among which the most important is the Tobique, which joins it on the left from the mountainous region of New Brunswick; and in the lower part of its course there are several lakes communicating with the river, the largest of which, Grand Lake, about 50 miles from the sea, is 30 miles in length, and varies from 3 to 9 in breadth. The river and bay of Miramichi are noticed in a separate article. The Ristigouche, which marks the boundary between New Brunswick and Canada, is formed by five main branches; and from this circumstance it derives its name, which signifies in the Indian language, "the river that divides like the hand." It has a length of 100 miles, and falls into the Bay of Chaleurs, having at its mouth a breadth of 3 miles and a depth of 9 fathoms. The Nipisigit waters the north-eastern part of New Brunswick, and falls into the Bay of Chaleurs after a course of 100 miles. Next to these the most important river in the province is the Peticodiac, which falls into the north-eastern extremity of the Bay of Fundy. It is navigable for large vessels to the distance of 25 miles from its mouth.

Geology and minerals.

The geological structure of New Brunswick resembles in its general arrangement that of most other parts of North America. The different formations extend either parallel to the branch of the Alleghanies, which crosses the country from S.W. to N.E., or parallel to the shores of the Atlantic. These mountains consist of granite, syenite, trap, porphyry, and other rocks; and in other parts of the province the Silurian, the Carboniferous, and the Old Red Sandstone strata occur. The geology of the interior of New Brunswick is not minutely known, owing to the country being so little cleared. Several excellent salt springs are found, especially in Sussex Vale, to the N.E. of St John's. Many of the strata of New Brunswick are very rich in fossil remains, which are remarkable in many cases for the distinctness and perfection with which they have been preserved. Of the mineral riches of the province, the most important item is coal, of which there is an immense quantity to be found. A vast coal-field occupies the central counties, covering an area of between 7500 and 10,000 square miles, or about one-third of the whole extent. Iron has been found in great abundance, and of excellent quality for steel, at Woodstock on the St John; and copper on the banks of the Nipisigit.

Climate and agriculture.

The climate of New Brunswick, like most of the adjacent parts of North America, is more subject to extremes than places of the same latitude in the Eastern Continent. At Fredericton the temperature ranges from 35° below zero to 95° above, and the mean temperature is about 42°. The severest part of the winter is from the middle of December to the middle of March; but the deepest snows do not fall till the end of February or beginning of March, when the winds blow from the E. with great fury, piling up the snow in drifts and banks. About the middle of March the south winds begin to blow with considerable strength, and soon afterwards the ice disappears from the rivers and lakes, and the country becomes fit for the plough. The spring is short, and generally cold and rainy; but during the summer very little rain falls, except in thunder-storms, which are frequent. The finest part of the year in New Brunswick is the autumn, and especially what is called the Indian summer, which occurs in the month of November. At this period the varied hues of the forest, the dryness and clearness of the atmosphere, and the brilliancy of the northern lights, all combine to increase the beauty of the scenery. The climate of the coast is somewhat more moist than that of the interior. The clearing of the country, which is rapidly going on, seems to be producing a gradual increase in the mildness of the inland regions; for while the winter formerly lasted for six months, it now rarely exceeds three or four. The climate is extremely healthy: epidemics are rare; rheumatism, low-typhus, and consumption are the only prevalent diseases; and there have been many remarkable instances of longevity in the province. The soil of New Brunswick is very good; and though the severity of the winters is unfavourable to the growth of some kinds of crops, potatoes, turnips, pulse, wheat, oats, rye, and barley thrive extremely well here. The largest crop raised, however, is that of hay, which is not only sufficient to supply the cattle with fodder, but is also exported in considerable quantities to the United States. The forests of New Brunswick, having been as yet but partially cleared, and as the occupation of cutting and sawing wood is more profitable than that of farming, agriculture has made but little progress, and the produce of the country is not sufficient to supply the wants of the inhabitants. The cultivation of the land, however, is rapidly extending; and improvements are being gradually introduced, which will render the produce of the soil more commensurate with its natural fertility. The amount of land under cultivation in the province in 1851 was 643,954 acres; and the crops raised in 1855 were,—of wheat, 206,635 bushels; of barley, 74,300; of oats, 1,411,164; of buck-wheat, 689,004; of Indian corn, 62,228; of pulse, 42,663; of turnips, 539,803; of potatoes, 2,792,394; of other roots, 47,880; and of hay, 225,093 tons. The number of horses in the same year was 22,044; of horned cattle, 106,263; of sheep, 168,039; and of swine, 47,932.

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Industry and commerce.

Besides farming, the people of New Brunswick are employed for the most part in the fisheries; in the lumbering business, as it is called,—that is to say, in cutting down timber from the woods, and preparing it for exportation; and in ship-building. The nature of the coasts of the province affords great facilities for fisheries; and the great abundance of fish which is to be got here would render fishing a profitable pursuit. It is not, however, carried on to a very great extent; for though many of the inhabitants of the coast pursue this occupation, along with those of farming and lumbering, yet the demand for timber and the scantiness of the population give greater encouragement to other occupations; while the idleness of the people and the encroachments of American fishermen prevent this employment from being prosecuted with as much activity as it might be. In consequence of the recent reciprocity treaty with the United States, admitting the produce of the colonial fisheries free of duty into that country, it is believed that the fisheries of New Brunswick will be more actively carried on and more highly valued than hitherto. The principal seats of the fisheries are in the harbour of St John's, and on the islands at the mouth of the Bay of Fundy. Cod, haddock, herring, and mackerel, are the principal fish got here; and the total value of the fisheries in the Bay of Fundy was, in 1850, L.52,700. The occupation of lumbering, in which a great part of the inhabitants are employed, though it is not favourable for the agricultural progress of the country, serves to clear out and open up the forests; and produces an active, hardy, and industrious set of men. The timber is floated down the rivers to the saw-mills, of which there are in the province a large number. The exports of New Brunswick consist principally of timber and fish. The total value of the wood exported in 1854 was L.740,157; and that of the fish, L.55,359. The total value of the exports in 1855 was L.826,381, and of the imports, L.1,431,330. The number of ships built in the province in 1854 was 135, and their tonnage 99,426; in 1855 the number of ships was 95, and their tonnage 54,561. The number belonging to the province on the 31st December 1854 was 878, tonnage 141,454; at the same date in 1855 the number of ships was 866, and the tonnage 138,292. The number of vessels that

New Brunswick.

entered the various ports in 1855 was 3442, tonnage 590,767; those that cleared in the same year 3381, tonnage 663,981. The number of saw and grist mills in the province in 1851 was 845, employing 4668 hands. There were also in the same year 125 tanneries, employing 255 hands; 11 foundries, employing 242; 52 weaving and carding establishments, producing 622,237 yards of cloth, and employing 96 hands; 8 breweries, producing 100,975 gallons of malt liquors; and 94 other factories, employing 953 hands.

Divisions and government.

The province is at present divided into fourteen counties, some of which, however, are but thinly peopled; and portions of land have been reserved for the aboriginal Indians, of whom there were in 1851, 1116 still remaining. The extent of land set apart for them is 61,273 acres. The government is in the hands of a lieutenant-governor, with an annual salary of L.3000, who is aided by an executive council of eight, a legislative council, and a representative house of assembly. The public revenue in 1855 amounted to L.93,916; and the expenditure in the same year was L.138,353. The judicial establishments of New Brunswick consist of a supreme court of four judges, a court of chancery, one of marriage and divorce, and one for the trial of offences committed at sea; the three last of which are presided over by the lieutenant-governor. There is also a court of vice-admiralty, and one of probate. The number of barristers in the colony, practising also the business of attorneys, was, in 1849, 155. The military force of the colony consists of a regiment of yeomanry cavalry, 3 separate troops of cavalry, a regiment of artillery, and 18 regiments of infantry, numbering in all 27,200 rank and file.

Religion and education.

The religious sects in New Brunswick are Episcopalians, Presbyterians, Methodists, Baptists, and Roman Catholics. None of these sects are supported by the government; but the Bishop of Fredericton takes precedence next to the lieutenant-governor and the commander of the forces. The diocese of Fredericton was created in 1845, and included in 1849 a bishop, an archdeacon, 33 rectors, and 8 curates, with 61 churches, capable of containing 17,920 people. The synod of New Brunswick in connection with the Established Church of Scotland consists of 13 ministers; and the synod in connection with the Free Church of Scotland consists of 17 ministers. The Wesleyan Methodists had, in 1847, 21 ministers and 33 local preachers in the province. The Baptists, who are divided into various sects, had, in 1846, 41 ministers; and the Roman Catholics, in the same year, 1 bishop and 24 priests. The whole number of places of worship in the colony in 1851 was 423. Education is well attended to in New Brunswick. There is a university at Fredericton, founded in 1828, and constituted after the model of those of Oxford and Cambridge. It receives annually from the crown a grant of L.1000, an equal sum from the provincial legislature, and has an endowment of 6000 acres of land near Fredericton. There are also Baptist and Methodist colleges in the province. Grammar and parish schools have been established in every county; the management of the former being in the hands of a board of trustees appointed by the lieutenant-governor and council, who themselves form a board of education for the superintendence of the parish schools. The parish schoolmasters receive government allowances, varying from L.18 to L.30 per annum. The whole number of schoolhouses in 1851 was 798. The public charitable institutions consist of a marine hospital, a lazaretto, and a provincial lunatic asylum. The amount of money expended in 1854 for educational and charitable purposes was L.17,269.

History and population.

The early history of New Brunswick is closely connected with that of Nova Scotia, of which it originally formed a part, when that province, then called Acadia or New France, was under the French dominion. The earliest attempt at colonization here was made in 1639; and in 1672 a number of French emigrants settled on the Miramichi and in other parts of the country. In 1713 New Brunswick was ceded to Great Britain, in terms of the treaty of Utrecht. The country was first settled by British colonists in 1764; and in 1784 New Brunswick was separated from Nova Scotia, and made a distinct province. It was originally peopled by several different Indian tribes; but these have all now disappeared except two,—the Micmacs and the Melicetes,—who, though resembling each other in physical appearance, differ considerably in their origin and language. They wander in families about the country; but an annual council is held, at which arrangements respecting their hunting, fishing, and other affairs, are made. The European inhabitants of the province consist to a large extent of descendants of royalists from the United States, who left their country at the American revolution, that they might remain under the British sway.

New Brunswick.

Principal towns.

The capital of New Brunswick is Fredericton, in the county of York, on the St John, 88 miles from its mouth. It stands on a plain bounded on one side by the river, which is here three-fourths of a mile broad, and on the other by a range of hills, 2 miles long and half a mile wide; and it is regularly built with long and straight streets. The most of the houses are of wood, but the public edifices are of stone, and some of them are very handsome. This town has a cathedral, five or six churches, a province-hall for the accommodation of the courts of law and legislature, a government-house, library, barracks, and other buildings. Pop. about 6000.

St John's, the principal commercial town in the province, is situated on a rocky promontory at the mouth of the St John River, in N. Lat. 45. 20., W. Long. 66. 3. It is regularly and well built; but the streets are in some places very steep, although much labour has been expended in reducing them to a level. There are many handsome public buildings of stone, brick, and wood, among which are a court-house, church, and bank. The extreme point of the promontory is defended by two batteries; and here are also barracks and military stores. The number of new vessels registered at St John's in 1854 was 97 (besides which 11 vessels were built for owners in the United Kingdom), aggregate tonnage 81,379; in 1855 the number was 76, and the tonnage 40,986. At 31st December 1855, 566 vessels, of 110,451 tons burden, belonged to the port. The number of vessels that arrived in 1851 was 1527, tonnage 282,450; those that cleared 1545, tonnage 324,821. The total value of the imports in the same year was L.626,398, and that of the exports L.535,441. Pop. about 12,000. The population of the various counties of New Brunswick in 1851 was as follows:—

Albert	6,313	Queen's	10,634
Carleton	11,108	Ristigouche	4,161
Charlotte	19,938	St John's	38,475
Gloucester	11,704	Sunbury	5,301
Kent	11,410	Victoria	5,408
King's	18,842	Westmoreland	17,814
Northumberland	15,064	York	17,628
		Total	193,800

NEW BRUNSWICK, a town of the United States of North America, capital of Middlesex county, in the state of New Jersey, stands on the right bank of the River Raritan, 26 miles N.N.E. of Trenton, and 30 S.W. of New York. The older part of the town, which is built on the low ground close to the river, has narrow and irregular streets; but on the hill which rises behind there is a more recent portion, with broad streets and many handsome edifices. Rutger's College, a building of dark red freestone, situated on a hill, has 7 professors, 66 students, and a library of 10,000 volumes. There is also here a theological seminary of the Dutch Reformed Church, with 3 professors, 34 students, and a library of 7000 volumes. New Brunswick has

Newburg ‖ Newbury-Port.

about ten churches, several schools, two banks, a court-house, and a jail. The Raritan is navigable as far as this place, and the town is connected with Bordentown, 42 miles distant, by the Delaware and Raritan Canal. It is also a station on the New Jersey Railway, and has a considerable trade. Pop. (1850) 13,070.

NEWBURG, a town of the United States, North America, state of New York, on the right bank of the Hudson River, 84 miles S. of Albany, and 61 N. of New York. The ground on which it is built gradually rises from the water's edge to the height of 300 feet. It is well built; and contains ten churches; a court-house; jail; theological seminary of the Associate Reformed Church, with about 11 students, and a library of 3200 volumes; several schools; and five banks. Newburg has large manufactories of cotton, wool, machinery, flour, plaster, leather, &c., and an active trade is carried on in grain, flour, and dairy produce, for which the surrounding country is famous. Pop. 11,415.

NEWBURGH, a royal burgh and market-town of Scotland, county of Fife, is situated on the right bank of the Firth of Tay, 9 miles E.S.E. of Perth. It is well built, and has one principal street running along the shore, and crossed at right angles by another leading to the harbour, which is formed by several piers extending into the river. The town has a town-hall with a spire, a large parish church, two United Presbyterian churches, Baptist and Independent churches, and several schools. The harbour is pretty good, admitting vessels of 500 tons burden; and some trade is carried on in corn, timber, linen, and coal. The inhabitants are principally employed in the weaving of coarse linens. In the neighbourhood of Newburgh are the ruins of the abbey of Lindores, and two curious antique crosses. The town is ancient, and was made a burgh in 1457. Pop. of the burgh (1851) 2638.

NEWBURY, a municipal borough and market-town of England, county of Berks, on the right bank of the Kennet, 16 miles W. by S. of Reading, and 56 W. by S. of London. The river is here crossed by a stone bridge of three arches; and the town, which is well built, has two principal streets, which are broad, and arranged in the form of the letter T. There is a large market-place in front of the parish church, which is a large but plain stone building of the age of Henry VII. The town contains also places of worship for Wesleyan Methodists, Independents, Baptists, Quakers, and Unitarians, and a new Episcopal church has recently been erected in the Gothic style. There is also in Newbury a substantial town-hall, jail, alms-houses, large workhouse, dispensary, literary institution with library, and several schools. The Kennet supplies water-power for several large corn-mills in the town and neighbourhood; and there are also silk and paper mills, malthouses, and breweries, in and about Newbury. The manufacture of woollen cloth was formerly carried on to a much more considerable extent than at present; and the place was of much importance in the days of posting, from its position on the road to Bath. It is now connected with the metropolis by a branch of the Great Western Railway. Some trade is carried on in malt and flour; and horse and cattle fairs are held thrice a year. Two engagements were fought here during the civil war in 1643 and 1644, in both cases with doubtful issue. Donnington Castle, not far from Newbury, to the N.W., was the property of Chaucer the poet, who is believed to have spent there the last years of his life. Pop. (1851) 6574.

NEWBURY-PORT, a seaport of the United States of North America, Massachusetts, situated on a gentle slope on the right bank of the Merrimack, 34 miles N. by E. of Boston. It is regularly built, with wide streets, some of which rise in terraces parallel to the river, and in its centre is a pond about six acres in extent, which is surrounded by fine pleasure-grounds. The custom-house is a large granite building, with a fine colonnade in the Grecian style; the city hall, a handsome building, has recently been erected at the cost of about L.7000; and there are also a court-house; 16 churches, belonging to various sects; and about 30 schools. There is a lyceum, at which lectures are delivered; and a public library has recently been established. Newbury-Port has five manufacturing companies, employing in all from 1500 to 1600 hands, and an aggregate capital of L.246,000. Cotton goods are principally produced; but iron, machinery, leather, boots, shoes, &c., are also among the manufactures. The harbour is large and safe, though there is a shifting sand-bank at its mouth. The registered and enrolled shipping of the port at June 30, 1852, had a tonnage of 29,430. The number of vessels that arrived in that year were 110, tonnage 9231; those that cleared 116, tonnage 10,140. George Whitfield died here in 1770, and his remains are buried in one of the churches of the town. Pop. (1850) 11,318; (1853) about 13,000.

Newcastle ‖ Newcastle-upon-Tyne.

NEWCASTLE, a market-town of Ireland, county of Limerick, situated on the Arra, 25 miles S.W. of Limerick, and 144 S.W. by W. of Dublin. It is a neat country town, with four principal streets and a large square. The parish church is a fine building; and the town has also a Roman Catholic church, two schools, town-hall, market-house, barracks, fever hospital, dispensary, workhouse, and the remains of an old castle that once belonged to the Templars, but is now the residence of the Earl of Devon. Coarse cloth is the principle article of manufacture here, and dyeing and bleaching are also carried on. Pop. (1851) 2513.

NEWCASTLE-EMLYN, a market-town of Wales, in the county of Caermarthen, is pleasantly situated on the banks of the Teifi, 16 miles N.W. by N. of Caermarthen, and 229 W. by N. of London. It was anciently called *Dinas-Emlyn*, or the "City of Emlyn;" and a castle existed here at a very early period. It was rebuilt in the time of Henry VII. by Sir Rhys-ap-Thomas, and the place then obtained the name of Newcastle. The castle was held by the royalists during the civil war, but after that period it gradually fell into decay, and only the ruins now remain. The town is well built, and contains an Episcopal, a Baptist, and other churches; a school; and a savings-bank. Some trade is carried on in cattle, for which there are eleven yearly fairs. Newcastle-Emlyn is included in the parish of Kenarth, which had in 1851 a population of 1980.

NEWCASTLE-UNDER-LYME, or *under-Lyne*, a market-town and municipal and parliamentary borough of England, in the county of Stafford, on the right bank and near the source of the Trent, 16 miles N. by W. of Stafford, and 150 N.W. of London. It is well though irregularly built, chiefly of brick, on the slope of two hills; and contains a handsome town-hall; two Established churches, one of which has an ancient square sandstone tower; besides Methodist, Independent, Baptist, and Roman Catholic churches; a literary and scientific institution, with a library; a theatre; a savings-bank; and a range of alms-houses founded by Christopher Monk, Duke of Albemarle, son of the celebrated general. The principal manufacture carried on here is that of hats, but there are also silk and paper mills, and a cotton factory; while shoes, clocks, and earthenware are also produced. In the neighbourhood there are coal-pits and iron-works. An old castle, of the time of Henry VII. formerly stood here, but no remains of it have been preserved. The borough returns two members to Parliament. Several fairs and cattle markets are held here annually. Pop. (1851) 10,569.

NEWCASTLE-UPON-TYNE is situated, as its name denotes, on the River Tyne, about 8 miles from the sea in a direct line, and exactly 10 miles by the course of the navigable channel. It is a county within itself, having its own sheriff and other officers distinct from the county of Northumberland, of which it originally formed part. The assizes for Northumberland are, however, still held in Newcastle,

Newcastle-upon-Tyne.

the court-house and its precincts being exempt from the jurisdiction of the municipal authorities. The Tyne is formed by the confluence of two streams, of which the North Tyne rises near a place called Deadwater, on the confines of Liddesdale in Scotland; the South Tyne has its source near the mountain of Crossfell in Cumberland. The point of junction is near Warden, a village 2 miles W. of Hexham, from which town the united stream flows past Newcastle, and thence between the towns of North and South Shields, discharging its waters into the German Ocean at Tynemouth, the ruins of the ancient monastery at which place forms a conspicuous landmark on the north of the entrance to the port. In the night a revolving light is constantly kept burning, and exhibits a face every minute. The River Tyne commissioners are at this time (1858) erecting substantial stone piers at the entrance of the harbour, which, when completed, will add greatly to the safety of ships trading to the Tyne.

Navigation.

Within the river, near the town of North Shields, there are two lighthouses for the use of vessels passing over the bar. There are three warping buoys within the river, two on the south and one on the north side; and in addition to these there is a distinguishing buoy on the north side, where the low light is situated. The tide flows up the Tyne from Shields to a distance of 18 miles; and at Newcastle Bridge it generally runs upwards about four hours and a half, and downwards about seven hours and a half. The perpendicular rise at the bar at Tynemouth is about 18 feet, and at the bridge from 11 to 12 feet. It is high-water on the bar, at the full and change of the moon, at about three o'clock, if the weather be settled; but a strong northerly wind will sometimes make it high-water an hour sooner, and a strong southerly wind an hour later, than the regular course; and there will be at times 2 or 3 feet more water on the bar with a strong northerly wind than with a strong southerly one. The commissioners are making great exertions to improve the navigation of the river, and employ a powerful steam-engine for the purpose of dredging.

Trinity House bridges.

Due precautions against accidents to shipping have been rendered necessary by the vast number of vessels that pass up and down the Tyne; and an association, formed in 1825 at the Trinity House, has for its object the preservation of lives from shipwreck and the maintenance of a life-boat at South Shields. The pilots on the river, and the sea-pilots connected with the port of Newcastle, with all its creeks and harbours, which extend from Holy Island on the north to Whitby on the south, are about 800 in number, and are under the regulation of the corporation of the Trinity House, who have a spacious hall, a chapel of very ancient workmanship, and alms-houses for poor brethren and widows, situated in Trinity Chare, near the quay. This ancient society is governed by a master (elected annually) and twelve brethren, who hold a common seal. The charter of this corporation was renewed by King Henry VIII. in 1536, and confirmed by Queen Mary in 1553, and also refounded by Queen Elizabeth in 1584. The bridge was founded in very ancient times, and consisted of wood. It was once burnt, and at subsequent periods was more than once carried away by the floods. The existing bridge was built between the years 1775 and 1799. It was only 21 feet wide, which, as the population and trade increased, was found very inconvenient; and in 1801 it was enlarged and widened, and is now 33 feet 6 inches in width. It connects the town of Newcastle with its suburb Gateshead, which is in the county of Durham. The inadequacy of this means of communication between the opposite sides of the river was long a subject of complaint, and several attempts were from time to time made to secure the erection of a second bridge on a high level, so as to avoid the dangerous declivities of both banks. All these failed in consequence of the magnitude of the capital required, until the formation of a company to complete the eastern line of railway communication between London and Edinburgh. The promoters of this scheme, now carried into successful operation, undertook, on the solicitation of the inhabitants and others interested, to make the bridge which was necessary for the transit of the railway available also for ordinary traffic; and to their liberality and enterprise, under the scientific direction of Mr Robert Stephenson, the public are indebted for that magnificent structure, the "High-Level Bridge." The design is as remarkable for its originality as for its grandeur; the structure consisting of two distinct roadways, one above the other,—the lower appropriated to ordinary traffic, the upper to the railway,—their respective elevations above the level of the river being 90 and 118 feet. The piers of the bridge are of stone, and are six in number,—one on the margin of the river on each side, and four in the stream, the distance between each being 124 feet. The railway works within the town of Newcastle, including the High-Level Bridge and the purchase of property, entailed an expenditure on the company of upwards of half a million sterling.

Newcastle-upon-Tyne.

Quay and wall.

The quay lies immediately to the east of the old bridge, and was considered, previous to the introduction of wet docks in our principal ports, as the finest wharf in England. Its length was nearly 550 feet, to which a further length of 1000 feet has been added by the corporation. The new portion, however, still presents an unsightly appearance, in consequence of the delay which has occurred in effecting the contemplated removal of a mass of property of the very worst description, and the erection of buildings which would have presented a handsome elevation to the river. The old quay appears even more desolate, from the disastrous effects of a tremendous explosion which occurred in the neighbouring town of Gateshead in 1854, involving an unprecedented destruction of property on both sides of the river. The town-wall formerly ran between the warehouses on the quay and the river, to the great obstruction of commerce, but was removed about the middle of the last century. Other portions of the wall have from time to time been removed without any pressing necessity, and little of it now remains. Leland, who saw it in its integrity, says,—"The strength and magnificence of the walling of this town far passeth all the walls of the cities of England, and of most towns in Europe." Sir Ralf Sadleyr gives similar testimony.

Coal trade.

From an early period Newcastle has been chiefly indebted for its mercantile importance to the extensive coal-fields adjacent. The cinders of this mineral discovered amongst the ruins of several of the Roman stations in Northumberland show that its use was not unknown to the imperial legions in Britain, although the abundance of wood everywhere available for fuel necessarily confined the consumption of coal to the immediate locality in which it was produced. During the Saxon period we have no notice of coal either as an article of commerce or of domestic consumption, although it is probable that where the seams were easily accessible they were not altogether neglected. The earliest authentic records of the Newcastle coal trade, after the Conquest, is found in a charter of Henry III. to the burgesses, A.D. 1239, in which he grants them license to dig coal in the Forth and Castle field, within the liberties of the borough. From an inquisition in the reign of Edward I. it appears that, in consequence of the rapid development of this traffic, the revenues of Newcastle were then worth L.200 per annum, although they had been granted by King John at a fee-farm rent of L.100 per annum, which was more than their then estimated value. In 1306 the use of sea-borne coal must have been general in London, as in that year Parliament complained to the king of its infecting the air with noxious vapours, in consequence of which the use of coal was prohibited, and

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strict orders given to destroy all furnaces and kilns in which it was used. Coals, however, must have again come into use in 1327, as at the coronation of Edward III. a debt appears to have been due for this mineral; and in the same reign orders were issued relating to the measuring of coals; and such as were got in the field of Gateshead were to be taken across the Tyne in boats, and, after paying the custom-duty, to be sent to any port of the kingdom, but to no port out of the kingdom except to Calais. About the year 1338 the Prior of Tynemouth granted colliery leases. In the year 1582 Queen Elizabeth obtained a lease for ninety-nine years of the manors and royalties of Gateshead and Whickham for L.90 per annum, which caused the price of coals in London to rise to 9s. the chaldron; upon which the lord mayor made applications to Lord Burleigh that the price might be reduced to 7s. In 1615 the trade appears to have employed 400 sail of ships, some of which sailed to France, and others to the Netherlands. During the civil wars the trade and the prices of coal fluctuated much, as at one time London was with the Parliament, and Newcastle with the royal party. In 1675 the shipping of Newcastle was estimated at 80,000 tons. In 1710 the annual average export for the three preceding years had amounted to 178,143 chaldrons, and in 1776 to 260,000. The following account will show the vast but gradual increase since that time:—

An Account of the Quantity of Coals shipped at Newcastle from 1794 *to* 1835, *distinguishing those sent Coastwise and those over Sea.*

Year.	Coastwise.	Over Sea.	Year.	Coastwise.	Over Sea.
	Chaldrons.	Chaldrons.		Chaldrons.	Chaldrons.
1794	388,724	39,935	1820	756,513	44,826
1800	537,793	47,487	1825	687,029	51,444
1805	552,827	49,572	1830	817,870	74,456
1810	632,299	17,258	1835	853,359	116,803
1815	650,209	42,834			

The preceding account is given in Newcastle chaldrons, which weigh 53 cwt., but the London chaldron weighs only 28 cwt. The former contains 68, the latter 36 Winchester bushels. Since the duty on coals water-borne ceased the account of the quantities shipped has been kept with less correctness.

Coals Shipped from the Port of Newcastle from 1849 *to* 1857.

Year.	Coastwise.	Foreign.	Year.	Coastwise.	Foreign.
	Tons.	Tons.		Tons.	Tons.
1849	2,127,558	778,465	1854	2,138,311	1,345,456
1850	2,252,293	1,007,716	1855	2,014,760	1,417,640
1851	2,049,846	1,001,939	1856	1,942,843	1,649,788
1852	2,157,273	1,057,463	1857	2,082,001	1,773,363
1853	2,131,417	1,032,566			

The number and tonnage of vessels registered as belonging to the port of Newcastle on 31st December 1856 were,—Sailing-vessels under 50 tons, 110; tonnage, 3083: above 50 tons, 452; tonnage, 124,830: steam-vessels under 50 tons, 81; tonnage, 1364: above 50 tons, 23; tonnage, 7621. During 1856 there entered and cleared at the port in the coasting trade,—Sailing-vessels, inwards, 2172; tonnage, 179,281: foreign, outwards, 9860; tonnage, 1,262,076: steam-vessels, inwards, 525; tonnage, 112,325: outwards, 782; tonnage, 196,713. In the colonial trade,—Sailing-vessels, inwards, 70; tonnage, 17,040: outwards, 151; tonnage, 59,019: steam-vessels, outwards, 1; tonnage, 16. In the foreign trade,—Sailing-vessels, inwards, 3816; tonnage, 593,339: outwards, 6697; tonnage, 1,217,689: steam vessels, inwards, 103; tonnage, 33,452: outwards, 119; tonnage, 31,341.

Lead.

The export of lead from Newcastle, although much inferior in importance to that of coal, is of still greater antiquity. The lead mines are situated in the mountainous districts in the west of Northumberland and Durham, and in the adjacent parts of Cumberland, from which the produce is conveyed to Newcastle for shipment. The discovery of the mines of Cumberland in the reign of Henry I. is noticed in the Chronicle of Robert de Monte; and those of Durham were probably known at as early a period. The latter were granted by King Stephen to his nephew Hugh Pudsey, Bishop of Durham. The Cumberland mines were gradually extended into Northumberland; and in the reign of Richard I. by much the more valuable portion was in the latter county. In the earliest records the mines both of Cumberland and Durham are described, not as lead but as silver mines, from the abundance of that precious metal which they contained. Those of Cumberland were let to the royal moneyers at Newcastle and Carlisle, and those of Durham probably supplied the mint which pertained to that episcopate. The pipe rolls of Cumberland and Northumberland afford several instances of the transport of lead from the former county for export from Newcastle in the reign of Henry II. The productiveness of these mines continues undiminished; and large quantities are yearly exported from Newcastle, both in pigs and in a manufactured state. The manufactures carried on here include patent shot, and all other preparations of lead, whether for pigments or otherwise.

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Glass.

The manufacture of glass was first introduced into England by emigrants from Germany, who established themselves in the neighbourhood of Newcastle in the reign of Queen Elizabeth. The trade has continued to flourish ever since, and is now extensively carried on in all its branches—bottle, crown, sheet, and plate glass.

Iron works.

Works for smelting iron have been established in this district for many years, but these have been multiplied to a great extent within a short period. Various branches of the iron manufacture are also carried on, including three very extensive establishments for building locomotive engines; one of them set on foot by the late George Stevenson, father of the locomotive system, and now conducted by his son, Robert Stevenson, C.E. The building of iron ships has also been recently introduced on a very extensive scale. Since the year 1816 a most important business has arisen in the neighbourhood of Newcastle, namely, the production of crystals of soda and mineral alkali by the decomposition of common salt. Besides these, there are manufactures of paper of all descriptions, and mills for the crushing of linseed; and the manufactories of copperas, coal-pitch, spirits of tar, varnishes, soda, aquafortis, whiting, glue, vinegar, and soap, are numerous and extensive.

The imports are various, but the principal articles are corn, wine, spirits, fruits, sugar, tobacco, tea, coffee, butter, cheese, tallow, hides, oak-bark, rags, flax, hemp, linen yarn, mahogany, deals and other timber, spars, masts, cordage, tar, iron, and what is necessary for the equipment of shipping. This view of exports and imports accounts for the number of vessels which have entered this port in successive years from foreign countries.

Ancient history.

Newcastle occupies the site of the Roman fortress of *Pons Ælii*, one of the stations on the Wall of Hadrian, which traversed the island from the Tyne to the Solway Firth. In the immediate vicinity the Saxon kings had a villa or occasional residence, called *Ad Murum*, celebrated, according to Beda, for the baptism within its walls of two royal converts—Sigebert, King of the East Saxons, and Pæda, the son of Penda, King of Mercia. At the period of the Norman conquest the Roman station was known as *Monkchester*, having probably been used as a place of refuge by the brethren of some of the numerous monastic establishments which existed in the neighbourhood prior to their destruction by the Danes, towards the close of the ninth century. The castle, which gives name to the pre-

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sent town, was built by Robert, the eldest son of William the Conqueror, on his return from a hostile expedition into Scotland, A.D. 1080. William Rufus is said to have fostered the growth of the infant community, as well by grants of privileges as by pecuniary aid. The particulars of these concessions rest on the authority of the metrical annalist Hardyng, a comparatively recent historian; but the general truth of his narrative is confirmed by the ascertained position of Newcastle in the succeeding reign. The "Laws and Customs of Newcastle" under Henry I. bespeak the advanced maturity of the borough, and the amount of royal favour which it must have experienced. In the reign of Stephen, Newcastle, with the rest of Northumberland, was enjoyed in succession by the Earls Henry and William, the son and grandson of David I., King of Scotland, but was taken from the latter by Henry II. on his accession to the crown of England. King John granted several charters to the burgesses; amongst others, one conferring the right of holding the town in fee-farm, instead of at the will of the crown. Henry III. further extended their immunities by authorizing the election of a mayor out of their own body, who should preside over them, instead of a provost, as heretofore, appointed by the crown. The enfranchisement of the borough from the dominion of the sheriff of Northumberland, and the liberty of electing a sheriff of their own, was conceded to them by Henry IV. Several additional immunities were granted by successive charters, all of which were, in the reign of Elizabeth, condensed and confirmed by what was known then as the "Great Charter;" and that, being afterwards slightly changed in the reign of James I., continued till the passing of the existing law in 1835. By that law the town has been divided into eight wards for the purposes of that act, and has now fourteen aldermen, forty-two councillors, a mayor, and sheriff, with justices of the peace, nominated by the crown. It returns two members to Parliament.

The revenue of the corporation is very large, amounting in 1856 to L.82,000, arising from dues on coal and cinders, rents of property, tolls, &c.

Docks, &c.

The corporation were, up to 1850, conservators of the Tyne, but in that year they were superseded by a commission composed of members from Newcastle, North and South Shields, Gateshead, &c. By the Tyne Improvement Act, which received the royal assent on the 15th July 1850, the conservancy of the River Tyne is transferred from the corporation of Newcastle to the "Tyne Improvement Commissioners." Those commissioners are in number 18,—viz., 4 life commissioners named in the act, and 6 elected annually by the Newcastle council, 3 by the Tynemouth council, 3 by South Shields council, and 2 by Gateshead council. The elections of river commissioners by the respective councils takes place on the 9th November in each year. By the Tyne Improvement Act 1852, additional powers are vested in the commissioners; and they are, by that act, authorized to construct a dock at Hayhole, to be called the Northumberland dock, and to form piers at the mouth of the river. The Northumberland dock has since been completed, and the two piers are in a state of considerable forwardness. By the Tyne Improvement Act 1857, the commissioners are also authorized to construct a deep-water dock at Coble Dean, communicating by a junction with the Northumberland dock. Besides the corporation their are many guilds or companies, having chartered privileges, and halls for their assembling. There are the "Twelve Mysteries," founded between the years 1215 and 1621; the "Fifteen By-Trades," founded between 1426 and 1626; and the various companies, eight in number, created at different periods, like the others, between the years 1454 and 1675. These companies choose annually sixty-nine stewards, out of which number a body of nine is nominated, called the Herbage Committee, whose duty it is to superintend the improvement and enforce the regulations respecting the free commons, of 1200 acres, upon which the burgesses have the privilege of pasturing two cows each (and a free pasturage is thus afforded to 700 cows), and also to watch over the interests of the freemen, and of their respective fraternities. They have a revenue of about L.900, derived from ground-rents, way-leaves, and other sources.

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Town and county courts.

Newcastle being a county of itself, the courts of assize and *nisi prius* are held thrice a year at the guildhall at the Exchange. Those for Northumberland, in the county-courts at the Castle Garth, are held at the same time. There are also some inferior courts of justice held, such as the mayor's court, in which only free burgesses or their widows are sued, and in which are tried all cases relating to real or personal actions to any amount arising within the town; the sheriff's court, in which all actions are brought as in the mayor's court, but with this distinction, that they may be instituted against all other persons than free burgesses; the court of conscience, to determine all debts or actions not exceeding in amount forty shillings, which extends to all persons residing within the liberties of the town; and the court of guild, the chief business of which now is the admission of persons to their freedom, whether they are entitled to it by birth, or by an apprenticeship during seven years. Besides these, a court of admiralty is occasionally held, the principal duties of which consist in preventing injury from being done to the river or to the salmon fishery.

Population.

The population of Newcastle has advanced in nearly the same proportion as that of the other towns of the kingdom. In 1801 it amounted to 28,366, in 1811 to 27,587, in 1821 to 35,181, in 1831 to 42,760, in 1841 to 69,430, and in 1851 to 87,784. But each of these accounts is materially deficient, owing to their exhibiting only the number of inhabitants within the limits of the burgh; and does not include those of its populous suburbs. In 1851 Gateshead alone had 25,568 inhabitants. Annual rental 1857, Newcastle, L.351,408; Gateshead, L.75,749.

Public buildings.

The public buildings for religious purposes are numerous. Those of the Established church claim the first attention. Of these, the mother church of St Nicholas is probably the oldest, and certainly the most striking. It was founded in the year 1091, by Osmond, Bishop of Salisbury, and placed under the jurisdiction of the bishop of Carlisle. The edifice was burned in 1210, and the present structure finished in 1359. The interior of the church is 242 feet; and on entering it by the great western door, the spectator is struck with mingled impressions of delight and solemnity, from the general and noble effect produced by the view. Some considerable improvements in the arrangement of the pews made in 1783 have adapted it for accommodating a congregation of more than 1200 persons. The organ is a remarkably fine instrument. The framework is mahogany, and the two pillars in front are magnificent; the centre is surmounted by the figures of two recumbent angels, and the compartments of the front are embellished with a variety of richly-gilt pipes. Several fine marble monuments have recently been erected on this edifice. A public library is attached to this church, formed by donations at different periods since the year 1661, but principally by Dr Tomlinson.

St John's church is an ancient structure, and supposed to have been built in the latter end of the thirteenth century; but it has since been enlarged and beautified at different periods. The great eastern window contains some curious ancient specimens of stained glass. By the erection of some new galleries and other arrangements of pews, it has been made capable of seating, including scholars in the aisles, more than 1400 persons. It has a square steeple with four pinnacles, a clock and six bells, with a large burying-ground adjoining.

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St Andrew's church is said to have been built by David king of Scotland, who died in 1153. It still exhibits some specimens of Anglo-Norman architecture, though many alterations have been made at different periods. Being near the town wall, it suffered much during the siege of 1644, and was long afterwards closed. It is furnished with a new organ, and the interior so arranged as to accommodate 1300 hearers, besides 200 children. Near to it is the burying-ground, which, by the removal of some houses in 1824, is laid open to public view, and handsomely surrounded by palisades.

All-Saints' church is a modern structure, having been erected between the years 1786 and 1796, at an expense of L.27,000, raised by an assessment upon the owners of houses in the parish. It has a stately Doric portico at the entrance, from which there rises an elegant spire to the height of 202 feet from the ground. It has a fine set of bells and a clock. It contains a spacious gallery, and the whole seat-room will accommodate near 1200 persons, and 270 children of the charity schools, who have seats in the gallery. This building was erected on the site of an ancient church which existed before the year 1284, but which was considerably larger, and capable of containing 2000 persons.

St Ann's church is, properly speaking, a chapel of ease to the parish of All-Saints. It was erected in 1768, on the foundation of an ancient building, at the expense of the corporation. It has a large school attached to it, in which boys are instructed in reading, writing, and arithmetic, on very cheap terms. The church has seat-room for about 500 perons.

St Thomas' church is a chapel of ease to the parish of St Nicholas. It was begun in 1828, and finished in 1830. It is an elegant structure, built in the early English style. The church is 135 feet in length and 63 feet in breadth, and has a tower 138 feet in height. It can accommodate from 1000 to 1100 persons. In the suburb or town of Gateshead is the church of St Mary, a new steeple to which was built on an old foundation in 1740. Its chief ornament is an elegant window of stained glass in the southern transept, which was presented to it in 1824. There is seat-room for 800 persons, including that for the charity children. Among the other churches are St Peter's, Oxford Street, and St Paul's, Arthur's Hill. This latter has been purchased by the Independents.

The places of worship for the various classes of dissenters from the Established church are numerous. From the vicinity to Scotland, the adherents of the Presbyterian form of worship are the greatest in number, occupying nine meeting-houses, most of them being of the Scotch kirk, and others secessions from it. The next largest portion of worshippers are the Wesleyan Methodists of the new and old connection, who have six chapels, one of them the largest place of worship in the town. The Independents occupy three chapels, the Baptists three, the Roman Catholics two, and the following persuasions,—viz., the Quakers, the Glassites, the Unitarians, and the Swedenborgians,—one each.

To the enterprise of Mr Richard Grainger the inhabitants of Newcastle owe the creation of almost a new town, built in a style of architectural beauty not inferior to any in the kingdom. After having built Eldon Square, Blackett Street, and several others of minor importance, Mr Grainger's first exertions, in an embellished style of architecture, were made on a large piece of ground adjoining the Leazes. Upon this he erected a parallelogram, consisting of upwards of fifty houses, all faced with polished stone, and of great elegance of design, and some of them of large dimensions. This undertaking was carried through by him at the same time that a spacious and splendid arcade was constructed in the centre of the town. The next attempt of this individual was more gigantic, and incurred an expenditure of half a million sterling. There existed in the very centre of the town a large piece of ground, about thirteen acres, which had originally been the gardens of the Grey Friars, and of a convent of Benedictine nuns. This completely cut off the communication between the opposite sides of the town, except by circuitous streets, and was partly occupied by stables, cow-sheds, and other nuisances. Mr Grainger conceived the idea of covering this extensive piece of ground with houses and markets of elegant construction. The purchase of the ground was effected, and the work begun, in the summer of 1834. This extraordinary undertaking consists of seven streets, some of them 80 feet broad, and all of stone, and highly embellished; besides a butcher market and a vegetable market, which alone occupy a space of more than two acres, and are entirely covered in. The butcher market consists of four avenues, 19 feet 4 inches wide, 27 feet high, and extending in length 338 feet. The vegetable market is connected with the butcher market, and consists of one stupendous hall, 318 feet long, 57 feet wide, and upwards of 40 feet high. A new theatre of great architectural beauty, a chapel for the Methodists of the new connection, a new dispensary, and a church, are also included in the plan. At the top of the principal street, named Grey Street, is a column 150 feet high, surmounted by a statue of Earl Grey. This elegant memorial is from a design by Messrs John and Benjamin Green of Newcastle, and the statue is by Bailey of London. The cost was defrayed by public subscription. Recently a large and massive building has been erected for the jail and house of correction, which cost L.49,000.

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Newcastle is as well supplied with those institutions which tend to the acquisition and diffusion of knowledge as any place of its extent in the kingdom. The Literary and Philosophical Society was founded in 1793. Its objects were—the discussion of the several branches of polite literature, and making inquiries into the situation and properties of the mineral productions of the neighbourhood, with the elucidation of the sciences applicable to commerce, antiquities, local history, biography, nautical inquiry, and other subjects. A new institution for delivering lectures has been united with it since 1802. A library, of more than 12,000 volumes, has been collected, and a valuable apparatus purchased for the illustration of chemistry and other branches of physics. The usefulness of this society has recently been greatly increased by the reduction of the annual subscription from L.2, 2s. to L.1, 1s., in consequence of a munificent donation to its funds by a spirited individual (Robert Stevenson, Esq., M.P.) The Natural History Society has erected an elegant building, which contains a museum of very great value. The published transactions of this society have raised the character of its members to a high rank in that science. The Newcastle Antiquarian Society hold their meetings in the old castle.

There is also an establishment recently formed, called "The Literary, Scientific, and Mechanical Institution," of which young persons may become members, and attend classes appointed for drawing, mathematics, chemistry, and the languages, at a very small expense. This society is also gradually forming a library, and various collections to assist in science and in art. There are likewise several subscription-rooms for newspapers,—especially good ones at the Exchange, Sandhill, and Central Exchange, Grey Street.

There is a well-endowed royal free grammar school, in which Greek and Latin were intended to be taught gratuitously; but a small fee is now paid by the scholars. It has access to some exhibitions at Lincoln College, Oxford. In several other schools many boys and girls are taught on the Lancasterian and Madras plans; and most of the churches and chapels have schools connected with them.

Newcome.

The institutions for benevolent purposes are numerous, of which the most prominent are Jesus' hospital, which provides for fifty old persons; Blackett, and the two Davidson's hospitals, in all for eighteen poor widows of clergymen or merchants; the Keelman's hospital, formed by that class of persons for the relief of their destitute, and chiefly maintained by a duty of one farthing per chaldron on all coals exported from the River Tyne; and the hospitals of St Mary Magdalen and of the Virgin Mary, the former for a master and three, and the latter a master and eight poor brethren.

The establishments for administering relief to the diseased or infirm poor are,—the infirmary, to which is now annexed a lock hospital, and which extends relief to the sick and lame poor of the counties of Newcastle, Durham, and Northumberland; the average annual number of in-patients being 800, and of out-patients 700; the dispensary, founded in 1777, supported by voluntary contributions, the object being the administration of medical and surgical aid to all diseased applicants, and the promotion of vaccine inoculation; the house of recovery, for the reception of persons afflicted with febrile diseases; the lunatic asylum, for thirty-eight males and the same number of females; the lying-in hospital, for poor pregnant women; the eye infirmary, and St Luke's hospital.

Markets, &c.

The markets are well supplied with provisions of all kinds; and the market for corn is one of the largest in the north of England. Water is abundantly supplied by the Water Company, from resources and reservoirs at Whittle Dean, 12 miles W. of Newcastle. There are no less than twelve public fountains, here called *pants*, in different parts of the town, but on account of the height of the reservoirs above the town, they are seldom now required, the pressure being sufficient; the fire-engines are under good regulation. There are companies for insurance against fire, as well as for ship and life risks. The town is well watched and lighted with gas.

The places of amusement are not numerous; the most prominent being the theatre-royal. The former house was opened in 1788, and was pulled down in 1836 to make way for the building of Grey Street. The new theatre, which is a structure of great beauty, was opened in February 1837. The assembly-rooms, built in 1766, are commodiously planned, having a ball-room 94 feet by 36, with a music gallery; adjoining are card-rooms, a room for private assemblies, and on the lower story is a supper-room, in which 460 individuals have been accommodated at the same time. There is a music hall appropriately fitted up, with the requisite auxiliary apartments.

The communication between Newcastle and the western coast is greatly facilitated by the Newcastle and Carlisle Railway, and to the north by the North British Railway. (J. H.)

NEWCOME, William, Archbishop of Armagh, a learned divine, was born in Bedfordshire in 1729. Having entered the university of Oxford, he was first a student of Pembroke College, and afterwards a fellow and tutor of Hertford College. His rise to honour and preferment was sudden and rapid. The degree of D.D. was conferred upon him in 1765; in the same year he became chaplain to the lord-lieutenant of Ireland; and in 1766 he was promoted to the bishopric of Dromore. All the while Newcome was closely directing his attention to biblical criticism, and was carefully maturing his views preparatory to publishing them. At length the results of his studies began to appear in quick succession. He published, among other works, *The Harmony of the Gospels*, in 1778; *The Duration of our Lord's Ministry particularly considered*, in 1780; *Observations on our Lord's Conduct as a Divine Instructor*, in 1782; *An Historical View of the English Biblical Translations*, in 1792; and *An Attempt towards revising our English Translation of the Greek Scriptures*, in 1796. Meanwhile, the author, after having been successively translated to the sees of Ossory and Waterford, had been installed in the archbishopric of Armagh in 1795. His death took place in 1800.

New England || Newfoundland.

NEW ENGLAND, a name given to the north-eastern portion of the United States of North America, comprising the states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. (See United States.)

NEWENT, a market-town of England, county of Gloucester, 8 miles N.W. of the town of that name, and 110 W. by N. of London. It consists of three irregular streets, and has a large old parish church, with a lofty spire, 2 dissenting churches, and a national school. Pop. (1851) 1547.

NEW FOREST. See Hampshire.

NEWFOUNDLAND, an island belonging to Great Britain, in the N. Atlantic Ocean, off the E. coast of North America, and forming the most of the eastern boundary of the Gulf of St Lawrence. It lies between N. Lat. 46. 38. and 51. 37., W. Long. 52. 44. and 59. 31.; and is separated from Labrador by the Straits of Belleisle, about 12 miles broad; and on the S.W. it approaches within 70 miles of North Point, in Cape Breton Island. Its form is generally triangular, but extremely irregular. Its area is about 36,000 square miles, and its coast line is estimated at nearly 1000 miles in length.

Surface of the country.

This vast island reposes upon an immense bank, a continuation of which has been observed all the way to Nova Scotia. It is apparently a mass of solid rock, having a very wild and rugged appearance from the sea, and being anything but inviting. On its south-eastern quarter Newfoundland is formed into a peninsula of about 80 miles in length, by from 15 to 60 in breadth; the isthmus which unites it with the mainland being not more than 4 miles in breadth. This peninsula is called Avalon. To the N. of it, and on the eastern side of the island, lies Trinity Bay, which is separated from that of Bonavista by a narrow neck of land, the point of which is Cape Bonavista. A long neck of land also divides Trinity Bay from Conception Bay on the northern side of Avalon. This bay ranks as the first district in Newfoundland, as well on account of the spirit and enterprise of the inhabitants who people its shores, as from its natural advantages of large harbours, coves, and the like. The scenery on this part of the coast is majestic, wild, and calculated to strike the beholder with awe. About 20 miles from Cape St Francis, the eastern boundary of Conception, are the bay and harbour of St John's, the capital of Newfoundland. A succession of bays indent the coast all round the peninsula of Avalon, the principal of which are—Trepassey Bay, St Mary's Bay, and Placentia Bay. The last, about 60 miles deep and 45 broad, lies between Cape St Mary and Cape Rouge, and contains several harbours and islands. It is separated from Fortune Bay by one of those long and narrow necks of land which are so common in the island. Fortune Bay is from 60 to 70 miles deep, and from 20 to 30 broad, receiving many rivers from the island lakes, and containing numerous harbours, the principal of which is Fortune Harbour, on the eastern side. St Pierre and Miquelon Islets are situated at the mouth of Fortune Bay. They were ceded to France in the year 1814, and the former contains a harbour which is the rendezvous of the French shipping, and the residence of the governor. From this point, all along the south side of Newfoundland to Cape Ray, which forms the N.E. entrance of the Gulf of St Lawrence, there are numerous bays, but none of sufficient size or importance to require particular description. On the western side, formed by Cape Anguille and Cape St George, is the Bay of St George, a large and deep inlet of the sea, into which several rivers, emerging from lakes in the interior, empty themselves. Further to the

Newfoundland. north is the Bay of Islands, formed by three arms, into which several rivers discharge their waters. One of these, called the Humber, is the most considerable yet discovered, its course having been traced for 114 miles to the north-westward, where it issues from a lake between 50 and 60 miles in length. As its name would indicate, this bay contains a number of islands, but none of any particular consequence. The next large indentation of the sea on the western side of Newfoundland is Bonne Bay, which has also rivers communicating with the lakes in the interior. The next bay is called Ingornachoix Bay, which contains two harbours; and to the north of it is St John's Bay, which receives the waters of Castor's River. Along the Straits of Belleisle, which separate Newfoundland from the coast of Labrador, are a few inconsiderable inlets; but beyond Cape Norman, the N.W. point of the island, is a large bay called Pistolet Bay; and further to the S. is Hare Bay, a deep gulf, the bottom of which intersects the island for two-thirds of its breadth at this point, branching off into innumerable bays and coves, sheltered by lofty hills. From this haven to White Bay, a very large inlet of the sea on the eastern side of the island, and thence to Cape St John, the coast is indented at short distances by commodious and much-frequented harbours. The Bay of Notre Dame and the Bay of Exploits are of great extent, and contain a vast number of islands, together with a thriving settlement called Twilingate. The River Exploits is about 70 miles long, but its navigation is obstructed by rapids, some of which have a velocity of nearly 10 miles an hour. This river connects the Red Indian Lake, a large sheet of water in the interior, with the Atlantic. From Cape St John to Cape Freels the coast is a continuation of ledges, shallows, islands, and rocks, but affords excellent fishing-grounds. Bonavista Bay contains several islands, and is itself indented by a number of small inlets and harbours. To the south of it is Catalina Bay, containing Ragged Harbour, which completes the circuit of the island.

After the exterior aspect of Newfoundland has been described, the interior comes naturally to be noticed. But this has as yet been very imperfectly explored. In 1823 a Mr Cormack succeeded in traversing its breadth from Conception Bay on the east to St George's Bay on the west; and from his account it appears, that this portion of it at least is much intersected with lakes and rivers, but poorly wooded, and of a rocky and barren soil. In this respect the island differs greatly from the other North American colonies, producing little timber but what is dwarf and stunted, except on the margins of bays and rivers, where spruce, birch, and poplar sometimes grow to a considerable size. Several high hills occur near the centre of the island, and the inland country is represented as generally undulating, so that lakes, rocks, marshes, and occasional elevations, with little or no vegetation, constitute its characteristic features. Geology. The geology of Newfoundland is nearly the same as that of the coast of Labrador. The prevailing formation is granite; but porphyry, syenite, trap, gneiss, mica, clay-slate, and other strata are also found. The island, it appears, abounds with minerals of various sorts. Coal and lime have been wrought in more than one part with some success; and there is little doubt as to the existence of copper, iron, and other mines, but it is not likely that they are very productive. There are excellent gypsum quarries near Cape Ray, and there is also a quantity of the mineral called marcasite, or iron pyrites, which the early discoverers mistook for real gold.

Climate. The climate, though severe, is healthy; the rate of mortality is below that of any part of the continent of America; and many of the inhabitants attain to a great age. The winter lasts from the beginning of December to the middle of April; and the most intense cold occurs in the months of January and February. During this period, owing to the clearness of the atmosphere, the brightness of the stars and northern lights have an exceedingly beautiful appearance. The snow does not lie long on the ground, and the cold is not so great as in Canada. The summer is short, but mild and pleasant; though the heat is sometimes great in that season. Newfoundland.

The most remarkable feature connected with Newfoundland is the fogs which prevail on its coasts. Those of the Gulf of St Lawrence are attributed to the coldness of the gulf-waters, which is supposed to be permanent a few feet below the surface, as well as at great depths. The fogs on the banks of Newfoundland are undoubtedly chiefly due to the meeting, in that point, of the cold air transported along with the polar current with the warm atmosphere over the gulf-stream. On the great bank the surface of the water is many degrees colder than it is in the neighbouring sea, and much less than that of the Gulf-stream, which is within a short distance of it.

Soil. The soil of Newfoundland in the vicinity of the rivers and lakes is generally rich and fertile, but it is covered in many places with a thick coating of moss; and in the eastern and southern parts of the island there are many tracts which are very sterile, and can only be made productive by constant manuring. The amount of cultivated land in the island, according to the census taken in 1845, was 82,259 acres.

Products. The most valuable vegetable productions are potatoes and cabbages; and, next to these, turnips, carrots, parsnips, radishes, and other garden roots, yield the most abundant crops. There were in the island, according to the census of 1845, 2409 horses, 8135 horned cattle, 5750 sheep, and 5791 goats. Carriboo deer, beavers, foxes, wolves, and bears abound; as well as the well-known Newfoundland dog, the true breed of which has become very scarce. Besides the great staple of the island, fish, which is here understood to mean cod, the numerous large and small sheets of water abound in divers kinds of excellent trout and eels of a great size; and lobsters, lance, herrings, mackerel, and salmon, are in great abundance; plaice, sole, halibut, and thornback, are likewise found on the coast. The capelin arrives periodically in such immense shoals as to change the colour of the sea. Herrings likewise arrive during spring and autumn in prodigious numbers. As a product of the coast may be mentioned kelp, which, with other sea-weed, is used as manure.

The importance of this colony has exclusively arisen from its fisheries. The different settlements are scattered principally on the shores of the eastern and southern sides of the island, but especially on the former. They are generally formed at the heads of the bays, particularly Conception Bay, thence to St John's, and southward to Cape Race. The principal are, besides St John's, the Bay of Bulls, Brigus, Cape Broyle Harbour, Ferryland, Fermore, and Renowes. St John's, the capital of the island, is a place of considerable strength, situated about 70 miles to the N. of Cape Race; N. Lat. 47. 35., W. Long. 52. 48. The harbour is one of the best in Newfoundland, being formed between two mountains, the eastern points of which leave an entrance, called the Narrows. This is the only assailable part, but it is so well defended that any vessel attempting to force an entrance would inevitably be destroyed. There is about 12 fathoms of water in the middle of the channel, with tolerably good anchorage-ground. The most lofty perpendicular precipices rise to an amazing height upon the north side, and the southern shore appears less striking in its altitude, only from a comparison with the opposite rocks. There is a light shown every night on the left side of the entrance, where there are also a small battery and a signal-post. Other batteries of greater strength appear towering above the rocky eminences towards the north. At about two-thirds of the distance between the entrance and St John's.

Newfoundland. what may properly be termed the harbour itself, there is a dangerous shelf called the Pancake, opposite the Chain Rock, so called from a chain which, in time of war, extends across the strait at that place, to prevent the admission of any hostile fleet. There are other fortifications besides those already noticed, planted upon the heights around the town, so as to render St John's perfectly secure against any sudden attack. Fort Townshend is situated immediately over the town, and is the usual residence of the governor. Forts Amherst and William are more to the north; and there is also a small battery perched on the top of a single pyramidal mount, called the Crow's Nest. The town itself consists chiefly of one long straggling street, extending nearly parallel to the shore on the north side of the port, from which branch out several narrow lines of houses, that can only be called lanes. The houses are chiefly built of wood, although diversified by some of brick and a few of stone; but they are somewhat irregularly placed, although the town has been much improved in this respect since the fire of 1846. The principal feature of the town consists in its multitude of wharves and fishing stages, which entirely line the shore. The government wharf is a fine broad quay, open to the accommodation of the public. St John's has repeatedly and severely suffered from fires. In 1815 a great amount of property was destroyed by a visitation of this sort. Other conflagrations took place in 1817 and 1818; and in 1846 the town was again almost destroyed by fire. There are nine places of public worship of various denominations at St John's, several school-houses, and numerous literary, scientific, and benevolent institutions. The town has a brewery, a distillery, a flour-mill, and a foundry. The number of vessels that entered the port in 1851 was 842, and their tonnage 103,016. Those that cleared in the same year were 703, and their tonnage 91,191. The trade of the place consists principally in the export of dried fish, and of seal, whale, and cod oil; and in the import of bread, flour, tea, sugar, and other necessaries of life. The resident population is about 19,000, and the fishermen amount to about 6000.

The following table shows the quantities of dried cod and seal-oil exported from Newfoundland for each year from 1851 to 1855, a quintal of fish being 100 lb.:—

Years.	Dried cod.	Seal-oil.
1851	1,017,152 quintals.	6968 tons.
1852	972,921 „	7333 „
1853	922,718 „	8137 „
1854	774,117 „	5667 „
1855	1,107,388 „	3760 „

The number of vessels that entered in 1855 was 1185, and their tonnage 150,603; those that cleared were 1017, and their tonnage 137,513. The total value of the imports in the same year was L.1,152,804; and that of the exports L.1,142,212. The government of the island is in the hands of a lieutenant-governor, with a yearly salary of L.3000, assisted by an executive council, not exceeding seven in number, appointed by himself. The legislature consists of a legislative council, above ten and below fifteen in number, appointed by the Crown, and a house of assembly of thirty members, elected by the people. The constitution received its present form in 1854, and at the same time the system of responsible government was established. The public revenue in 1855 was L.126,449, and the expenditure L.120,926. The public debt of the colony in the same year amounted to a total of L.150,000. The judicial establishments of the island comprise a supreme court, composed of one chief and two assistant judges; and three circuit-courts for the Northern, Central, and Southern divisions of the island. No religious establishment is supported by the public funds, but the bishop of Newfoundland receives a salary of L.300 a-year from the British Treasury, the remainder of the provision for the episcopate being supplied by the Society for the Propagation of the Gospel. There were in 1855 forty ministers of the Protestant Episcopal church in Newfoundland and the coast of Labrador, and sixty-six churches. The Roman Catholics, in the same year, had forty-nine churches; the Wesleyans thirty-seven churches, forty preaching stations, and thirteen missionaries; and the Established Church of Scotland, the Free Church, and the Congregationalists, had each a place of worship at St John's. A considerable part of the public money is devoted to the purposes of education; and this sum amounted in 1855 to L.8871. The number of schools aided by these grants was 219, and the number of scholars 13,602. The sum expended for benevolent purposes in the same year was L.17,787; and the principal charitable institutions are an hospital and lunatic asylum at St John's. Newfoundland.

When Newfoundland was first visited it was found to contain two distinct races of aborigines; the one termed Red Indians, and the other Esquimaux. Both are now almost extinct; the former, it is supposed, is entirely so, as deadly feuds were waged between them and the early settlers. Besides, the Mic-mac Indians, who were introduced into the island from Cape Breton and Nova Scotia, carried on with the Red Indians an exterminating war, which proved far more fatal to them than the hostilities of the Europeans. A female of this tribe was captured in 1818, and from her a vocabulary of their language was obtained.

Without dwelling upon the tradition which represents Newfoundland as having been settled at a very early period by one Biron, a sea-king or pirate of Iceland, we have authentic evidence of its re-discovery by John Cabot, on the 24th June 1497. Sailing under the commission of Henry VII. in these seas, he descried a headland, which, as a lucky omen, he called Bonavista, a name which it still retains. It was at that time inhabited by native Indians, three of whom he brought home, clothed in skins, and speaking a language which no person understood. It was afterwards visited by navigators from France and Portugal, who, reporting favourably of the abundance and excellency of its cod fishery, European fishermen were soon attracted to its coasts. In 1536 an English vessel attempted to winter upon the island, but the crew nearly perished from starvation. Not deterred by this failure, however, nor by that of a former attempt, Sir Humphrey Gilbert, in 1583, landed on the island with 200 followers, and, under a patent of Queen Elizabeth, took quiet possession of the country. Being, however, desirous of prosecuting his discoveries, his crews became disaffected, and, having separated into two parties, one of them returned home. Most of those who followed him were lost in a gale of wind off the Sable Island, and the remainder perished, along with himself, on their voyage homewards. Subsequent attempts were made to explore and settle Newfoundland, but it was not until the year 1623 that the first colony was established under Sir George Calvert, afterwards Lord Baltimore. His son was made governor of the colony, which he named Avalon, and soon afterwards proceeding thither himself, it increased and flourished under his auspices. Other individuals obtained grants of land; and, about the year 1654, fifteen settlements, comprehending 300 families, had been made on the island, notwithstanding the constant bickerings between the English and French, the latter having established a colony at Placentia. On the breaking out of the war after the accession of William III., these assumed a more serious character, and, after various recriminations, St John's was compelled to surrender to the French in 1696. The captors set fire to the fort and town, and destroyed most of the British settlements. To repair these losses, our government despatched a squadron; but

New Granada || New Hampshire.

the cowardice of one commander, and the ignorance of another, frustrated the design. The re-establishment of peace put an end to hostilities for the time; but they were resumed in 1702, during which year several of the French settlements were destroyed, and a great many fishing-boats were burned or captured. In the following year an expedition miscarried, and this circumstance encouraged the French to attempt the conquest of the whole island in 1705. For this purpose 500 men were despatched from Canada to the assistance of the garrison of Placentia, who, though repulsed from St John's, extended their ravages over the different settlements as far as Bonavista. In the year 1708 the French completely demolished the town of St John's; and, shortly afterwards, Carbonia, the only settlement of consequence remaining in our hands, was partially destroyed. From this time until the conclusion of the peace of Utrecht, the French remained in quiet possession of Newfoundland; but, by this treaty, the island, with all the adjacent ones, was declared to belong to Great Britain, the French being only allowed the use of the two islets of St Pierre and Miquelon. The revolutionary war in America occasioned fresh disputes as to the right of fishing upon the banks of Newfoundland. The New Englanders had hitherto enjoyed the right of taking fish, and on this being resisted, they retaliated, by refusing to supply the colony with many articles of provision upon which it depended. This dispute was settled by the treaty of Versailles in 1783, by which it was stipulated that the inhabitants of the United States should have liberty to take fish of every kind on the coast of Newfoundland, but not to dry or cure their fish upon the island. Pop. (1845) 96,864; (1850) estimated at more than 100,000.

NEW GRANADA. See GRANADA, *New*.

NEW HAMPSHIRE, one of the United States of North America, is bounded on the N. by Canada, E. and S.E. by Maine and the Atlantic Ocean, S. by Massachusetts, and W. by Vermont. It lies between 42. 41. and 45. 25. N. Lat., and between 70. 40. and 72. 35. W. Long.; extending in length about 185 miles, whilst its average breadth is about 50 miles, and its area is computed at 9280 miles. On the map its shape nearly resembles a wedge inserted between the states of Maine and Vermont, and having Massachusetts for its base. The line of coast is indented with small inlets of the sea, and skirted by a narrow sandy plain. At no great distance the country swells into a mountainous region, and New Hampshire has justly been called the "State of Hills," and also the "Granite State." Mount Washington, the highest peak of the White Mountain range, has a height of 6226 feet; and is thus, with the exception of Mount Mitchell, in North Carolina, the highest mountain in the Union E. of the Mississippi. Between the Merrimack and the Connecticut are situated many considerable mountains; the names of the principal heights being Monadnock, 3718 feet high; Kearsarge, 3067 feet; Car's Mountain, 1381 feet; and Moosehillock, 4636 feet. As a whole, the physiognomy of New Hampshire is bold and prominent, and, although rugged, often sublime in the highest degree. The mountains of the state are in the centre, with a zone of finely-diversified hill and dale country around, the hills consisting generally of stony and moist land, and affording excellent pasturage. The geological structure of the mountains of New Hampshire consists principally of granite and mica slate; the former predominating among the White Mountains, and the latter among the elevations farther to the S. The mineral resources of the state are considerable. Iron has been found in great abundance in many parts of the country; and there are also mines of copper, tin, lead, and zinc. Granite is more abundant here than in any of the other states; and fine marble has been found in considerable quantities. The general slope of the state is from N. to S., and in that direction the most of the rivers flow. Of these the principal are—the Connecticut, which forms the boundary between this state and that of Vermont; the Merrimack, flowing through the middle of the state; the Piscataqua, in the S.E.; and the Androscoggin, which flows for the greater part of its course in the state of Maine. The principal lake in New Hampshire is Lake Winnipiseogee, which is of an irregular shape, about 25 miles in length, and varying from 1 to 10 in breadth. Its depth is great, and the scenery is very picturesque and beautiful. There are also many smaller lakes, of which Umbagog, on the confines of Maine, Connecticut Lake, and Squam Lake, are the chief. The whole surface of the water in this state is estimated to amount to 110,000 acres. The climate of New Hampshire is severe, but less variable than that of Maine and of the other northern states. The winters are long, and the snow lies from November till April, and sometimes till May; while the mountains are covered with snow for the greater part of the year. The spring is generally wet and foggy, but great heat is often experienced in the summer, when the thermometer sometimes stands above 100°. The soil is in general not very fertile; but the labour and industry of the people have succeeded in rendering it productive of many valuable crops. The richest portions are those along the banks of the rivers, especially the Connecticut. The uplands afford good pasture ground; and the whole country, notwithstanding its few natural advantages, has a rich and flourishing appearance. The lower slopes of the mountains are thickly covered with forests of oak, pine, beech, maple, walnut, &c.; while on the lower regions elm, ash, birch, poplar, and other trees abound. The amount of cultivated land in the state in 1850 was 2,251,488 acres; and during the year ending June 1, 1850, the produce was 185,658 bushels wheat; 183,117 rye; 1,573,670 maize; 973,381 oats; 70,856 peas and beans; 65,265 buckwheat; 70,256 barley; 4,304,919 potatoes; 1,108,476 lb. wool; 6,977,056 butter; 3,196,563 cheese; 257,174 hops; 7652 flax; 1,298,863 maple sugar; 117,140 bees' wax and honey; 598,854 tons hay; L.51,781 orchard produce; and L.11,833 market-garden produce. The number of horses in the same year was 34,233; milch cows, 94,277; working oxen, 59,027; other cattle, 114,606; sheep, 384,756; and swine, 63,487; while the total value of live stock in the state was L.1,848,310. The state of New Hampshire is actively engaged in manufactures; for which great conveniences are afforded by the water power which is furnished by the different rivers and streams. There were in 1850, 3301 manufactories in the state, of which 44 were cotton factories, employing 2911 male, and 9211 female hands, having a capital of L.2,280,000, consuming L.1,008,210 of raw material, and producing 113,106,247 yards of cotton and 140,700 lb. of yarn, valued at L.1,839,708; 61 woollen factories, employing 926 male, and 1201 female hands, having a capital of L.507,850, consuming L.264,023 of raw material, and producing 9,712,840 yards of cloth and 165,200 lb. of yarn, valued at L.443,277; 29 iron-foundries, furnaces, &c., employing 390 hands, having a capital of L.49,700, consuming L.39,073 of raw material, and producing 6074 tons of iron, valued at L.80,850; and 163 tanneries, having a capital of L.92,076, consuming L.112,867 of raw material, and producing leather valued at L.187,586. Ship-building is carried on to a considerable extent in New Hampshire; and the number of vessels built in 1852 was 14, with an aggregate tonnage of 9515. The whole of the vessels owned in the state in the same year had a tonnage of 24,891, of which 2283 tons were engaged in the cod and mackerel fishing. The trade of the state is very inconsiderable, as there is only one port of entry in the state, viz., Portsmouth; while there are few rivers capable of affording facilities for inland navigation. The tonnage of the vessels that entered in 1850 was 11,044; of those that

New Hampshire.

New Hampshire.

cleared 8213. The number of vessels built in the state in the year ending June 30, 1856 was 10, and their tonnage 10,395. The total value of exports for the same year was L.1097, and of imports L.5068.

The government of the state is in the hands of a governor, who is appointed annually by the people, and has a salary of L.208. He is assisted by an executive council of 5 members; and there is also a senate of 12, and a house of representatives of 286 members, popularly elected. The judicial establishment consists of a supreme court, composed of a chief justice and four associates, and of a court of common pleas, having one chief justice and two associates. The supreme court has exclusive jurisdiction in criminal cases; and there is a right of appeal to it from the court of common pleas in civil cases where the matter in dispute exceeds L.20 in value. For legal purposes, the state is divided into five districts, in each of which the supreme court holds two annual terms. The amount of the public income for the year ending June 2, 1857, was L.43,636, and the expenditure for the same year was L.40,187. The total value of the taxable property in New Hampshire in 1856 was L.25,239,460; and in June 1857 the total number of banks in the state was 52, their aggregate capital L.1,048,185, and their circulation L.741,302. There were also at that time 20 savings-banks, of which the deposits were L.802,115, and the total means L.843,332. There are numerous railways in the state, crossing it in various directions, and communicating with the principal towns of New England. The total length of all the lines in operation in January 1857 was 480 miles. There are also several canals in New Hampshire; and telegraphs have been established between the principal towns. The number of churches in the state in 1850 was 602, being one for every 528 inhabitants; and of these the Baptists owned 180; the Christians 23; the Congregationalists 172; the Episcopalians 11; the Quakers 15; the Methodists 99; the Presbyterians 13; the Union Church 32; the Unitarians 13; the Universalists 36, &c. The total value of church property was L.291,995. The interests of education in the state are committed to the care of a board of commissioners from the several counties. The number of scholars in 1856 during the winter was 67,103; and in summer 58,203. The number of teachers was 1077 male, and 3042 female. The amount of money raised by taxation for schools was L.44,230; and the whole amount expended for district schools during the year 1856 was L.53,908. There were, in the same year, 89 academies and private schools in the state; and also a college at Hanover, with 16 professors, 251 students, and a library of 31,900 volumes; three theological schools belonging to Methodists, Congregationalists, and Baptists, having in all 99 students; and one medical school, having 5 professors, and 50 students. The principal charitable institution of the state is the lunatic asylum at Concord, which was opened in 1843, and has at present 170 inmates. It is supported by the public funds; and the receipts in 1857 amounted to L.5638, and the expenditure to L.5502. There is also a house of reformation for female and juvenile offenders, and a state prison at Concord. The earliest settlements in this part of the country were made by Mason and Gorges, who obtained in 1622, from James I., a grant of the land between the Merrimack and the Kennebec; and, in the following year, colonies were planted at Portsmouth and Dover. In 1641, the colonists placed themselves under the protection of Massachusetts, of which colony they continued to form a part until 1679, when their country became a royal province. It was, however, afterwards united with Massachusetts; and was finally, in 1749, made an independent colony. New Hampshire suffered very much at one period from the inroads of the Indians; but having escaped this danger, the colony rapidly increased in wealth and population. Although this state took an active part in the war of the American revolution, no important battles were fought within its territory, either at that time, or during the war of 1812. The capital of the state is Concord. Pop. (1850) 317,976.

New Haven || Newhaven.

NEW HAVEN, a town of the United States of North America, state of Connecticut, pleasantly situated on a plain at the head of New Haven Bay, an inlet of Long Island Sound, 76 miles N.E. of New York, and 160 S.W of Boston. The plain on which it stands slopes gradually to the sea, and is bounded on the other three sides by hills, which on the E. and W. form steep and rugged precipices, from 300 to 400 feet high. Three small rivers traverse the plain from N. to S.; the Quinepiack on the E., the Mill River which joins the former near its mouth, and the West River; and these rivers are crossed by several bridges. The town is regularly laid out, and very handsomely built; the streets are broad, and in general lined with rows of fine elms; and in the centre there is a public park, surrounded and intersected by numerous avenues of elms. On account of this conspicuous feature, New Haven has been called the "City of Elms." There are also several other squares; and the public burial-ground is beautifully adorned with trees, shrubs, and flowers. The state house is a handsome building of brick, covered with stucco, in the Grecian style, and contains halls for the legislature and courts of law. There are about 22 churches, many of which are remarkable for neatness and elegance. Of these 8 are Congregational, 4 Episcopal, 4 Methodist, 2 Baptist, 2 Roman Catholic, 1 Universalist, and 1 Jewish synagogue. There is also a handsome state hospital, built of stone, and placed on a rising ground. Yale College, which is next to Harvard, the principal university in the United States, was founded in 1700, and transferred to New Haven in 1717. It has extensive buildings, partly of brick and partly of stone; and that which contains the library is a handsome Gothic structure. It has 24 professors, 365 students, and a library of 63,500 volumes. There are at present five departments in this college—those of arts, divinity, medicine, law, and science. Yale College has a valuable museum of mineralogy and geology, which is the finest of the sort in the United States, and surpassed by few in the world. New Haven has also numerous schools which enjoy a high reputation, and several literary and scientific societies. It is connected by railway with the principal places in the surrounding country; and steamers ply daily between this and New York. The railway station for all the lines that lead to the town is a handsome building of brick with towers. The harbour is large and safe, but the shallowness of the water prevents the entrance of large vessels; and, though a long quay has been built into the centre, the continual accumulation of sand at the bottom has neutralized all the benefit that might have been derived from this erection. The trade of the port is chiefly with the West Indies, and mules form one of the principal articles of export. The number of vessels that entered from foreign parts in the year ending June 30, 1852, was 110, and the tonnage 21,356; those that cleared were 108, and the tonnage 20,580. The manufactures of the town are considerable; and the principal articles produced are carriages, clocks, India-rubber goods, boots, shoes, and hardware. Pop. (1850) 22,529; (1853) about 23,000.

NEWHAVEN, a village of Scotland, county of Mid-Lothian, on the shore of the Firth of Forth, 2 miles N. of Edinburgh. It consists for the most part of poor houses, inhabited by a fishing population; but there have been recently erected many handsome houses and villas, which are chiefly used as seaside residences. There are here an Established and a Free church; and a stone pier, which is convenient for small fishing-boats. Pop. 2103.

NEWHAVEN, a town and parish of England, county of

New Ireland || New Jersey.

Sussex, near the mouth of the Ouse, 8 miles E.S.E. of Brighton. It has a parish church, a dissenting church, and a national school. The harbour has recently been much improved, and it is now considered the best between the Downs and the Isle of Wight. Steam-packets sail regularly from this to Dieppe, performing the passage in four or five hours. Pop. (1851) 1260.

NEW IRELAND, an island in the South Pacific Ocean, between S. Lat. 2. 40. and 4. 52.; E. Long. 150. 30. and 152. 50. It is separated from New Britain on the S.W. by St George's Channel, and from New Hanover on the N.W. by Byron's Straits. It is about 200 miles long by 12 in average breadth; and the coasts are indented by several small harbours. The surface is hilly, the elevations attaining a height of 1500 or 2000 feet; but they are all covered with forests of bread-fruit, cocoa, and other trees. The lower parts are well cultivated, and produce the sugar-cane, the banana, yams, &c. Dogs, pigs, and turtles, are the chief animals. The inhabitants, like those of the neighbouring island of New Britain, belong to the race of Australian negroes. For a description of them see AUSTRALASIA. Fancy woods and tortoise-shell seem to be the only articles of commercial value to be obtained in this island.

NEW JERSEY, one of the United States of North America, lying between N. Lat. 38. 55. and 41. 21., and W. Long. 73. 58. and 75. 29.; and bounded on the N. by New York; E. by the Hudson River and Staten Sound, which separate it from New York, and by the Atlantic; S.E. by the Atlantic; S.W. by Delaware Bay; and W. by the River Delaware, which separates it from the states of Delaware and Pennsylvania. Its length from N. to S. is about 168 miles; its breadth varies from 37 to 70 miles; and its area is 8320 square miles. The northern part of the state is hilly, being crossed from S.W. to N.E. by several branches of the Alleghany ridge. Of these the principal are,—the Blue Mountains in the extreme N.W., Schooley's Mountain, the Trowbridge range, and First Mountain, further to the S.E. These hills, though not remarkable for their height, present in general a bold and picturesque appearance, and inclose beautiful and fertile valleys, containing some of the best land in the state. The west bank of the Hudson is skirted for the length of 20 miles by a ridge of rocks called the Palisades or Cloister Hill, which in some places rises steeply above the river to the height of 200 feet. The middle part of the state is the most agricultural portion, and has a rich and beautiful appearance. That part of New Jersey which lies S. of Trenton and Raritan Bay consists of a flat sandy plain, never rising above 60 feet from the sea level, except to the S.E. of Raritan Bay, where the Nevisink Hills rise to the height of 300 or 400 feet, and present a conspicuous object to the navigator as he leaves the harbour of New York. From the low sandy promontory called Sandy Hook, opposite to the entrance of New York Harbour, to Cape May, which forms the eastern boundary of Delaware Bay, the whole coast consists of a low sandy shore, having in some places, inlets and long, narrow, and shallow lagoons. The heavy surf of the Atlantic is constantly beating against this beach, and the form of the coast-line is being constantly changed. The principal inlets on this coast are Barnegat Bay, Little Egg Harbour, Great Bay, and Great Egg Harbour. Further inland there is a tract of salt marsh, which gradually gives place to the sandy plain of the interior. The shores of Delaware Bay are skirted by a similar salt marsh; but along the left bank of the River Delaware the land is more elevated, and a branch of the mountains of Pennsylvania crosses the river at Trenton, and forms, by a ledge of rock over which the waters roll, the Falls of Trenton.

The rivers of New Jersey, with the exception of the Hudson and Delaware, which merely bound the state, are not of great size. The Hackensack from the north, and the Passaic, which follows a circuitous course from the west, fall into Newark Bay; the former being navigable for small vessels to the distance of 15 miles, and the latter to that of 10 miles from the sea. The Passaic is remarkable for its falls near the village of Paterson, which are situated in the midst of wild and beautiful scenery; but the volume of water has been much diminished by being carried off for mills, and it is only in times of flood that the full magnificence of the cataract can be seen. The Raritan, from the west of the state, falls into the bay of the same name, and is navigable for 17 miles; the Great and Little Egg Harbour rivers fall into the Atlantic, and the Maurice falls into Delaware Bay, each being navigable for about 20 miles; and there are also numerous rivers, but none navigable, which discharge themselves into the Delaware. The hills in the north of the state consist for the most part of sandstone towards the west, and of gneiss towards the east; while in the valleys of this region are found strata of slate, sandstone, and limestone. The central and southern regions belong to the chalk formation, and contain beds of marl, which are of great value for manure. Besides these, the mineral riches of New Jersey consist of iron, which occurs in great abundance in various forms; copper, containing in some places silver ore; zinc, of which the mines in this state are among the richest in the Union; slate, marble, limestone, and granite. The soil of the country varies considerably in different parts; the central and southern regions, though not naturally rich in soil, may be easily made to produce excellent crops of wheat, maize, and potatoes; while the northern portions, though not very fertile, are well adapted both for agriculture and pasturage. The coldness of the climate is moderated in the south by the neighbourhood of the ocean; while in the north it resembles that of the south of the state of New York and the north of Pennsylvania. The mean temperature at Lambertville of the warmest month (July) for the year ending 30th June 1852 was 82°·43; that of the coldest month (January), 30°·74. The greatest heat in the same year was 97°, the greatest cold 16°·5, and the mean temperature of the year 57°·82. The central and southern parts of the state contain extensive forests of pine, much of which is used for charcoal, and sold at Philadelphia. There are also cedar swamps in the south of New Jersey; and the principal other trees that occur here are oak, hickory, sycamore, dogwood, &c. The quantity of cultivated land in the state in 1850 was 1,767,991 acres; and the produce in that year comprised 1,601,190 bushels of wheat, 1,255,578 of rye, 8,759,704 of maize, 3,378,063 of oats, 14,174 of peas and beans, 3,715,261 of potatoes, 874,934 of buckwheat, 91,331 of grass seeds, 375,396 lb. of wool, 9,487,210 of butter, 565,756 of cheese, 182,965 of flax, 156,694 of bees' wax, 453,950 tons of hay, L.126,511 worth of orchard produce, and L.99,006 worth of market produce. The number of horses in New Jersey in the same year was 63,955; of milch cows, 118,736; of working oxen, 12,070; of other cattle, 80,455; of asses and mules, 4089; of sheep, 160,488; of swine, 250,370; and the total value of the live stock was L.2,224,848. The state of New Jersey is, considering its population, extensively engaged in manufacturing industry. In 1850 there were 4374 manufactories, each annually producing goods to the value of L.100 and upwards. Of these, 21 were cotton factories, employing 616 male and 1096 female hands, having a capital of L.309,060, consuming L.138,880 worth of raw material, and producing 8,122,580 yards of cloth, and 2,000,000 lb. of yarn, valued at L.301,148; 41 woollen factories, employing 411 male, and 487 female hands, having a capital of L.102,970, consuming L.114,296 worth of raw material, and producing 771,100 yards of cloth, and 350,000 lb. of yarn, valued at L.242,590; 108 furnaces, forges, &c., employing 1996 hands, having a capital of L.536,891, consuming L.198,894

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worth of raw material, and producing 42,452 tons of cast and wrought iron, valued at L.390,881; 133 tanneries, with a capital of L.119,342, consuming L.88,237 worth of raw material, and producing leather valued at L.150,928; besides numerous breweries and distilleries, producing 34,750 barrels of ale, and 1,250,530 gallons of whisky and wine. The state of New Jersey, as it lies directly between the two largest cities of the United States, New York, and Philadelphia, is traversed by several lines of railway, which have in general for their object the connection of New York with Pennsylvania. In January 1857 the length of the railways in the state was 492 miles. There are also several canals, the total length of which amounts to 145 miles. The foreign trade of New Jersey is not very great; for, though it is bordered on one side by the sea, and on two sides by navigable rivers, and though there are several seaports within its limits, the neighbouring great cities and harbours of New York and Philadelphia carry off most of the direct commerce to these places. The exports for the year ending June 30, 1856, amounted to L.80, and the imports for the same year were L.576. There is, however, an important internal and transit trade carried on through this state. The number of ships built in the state in the same year was 75, and their tonnage 9543. There were, in January 1857, 46 banks, with an aggregate capital of L.1,371,406, and a circulation of L.991,533.

Government.

The executive power in the state is in the hands of a governor, who is elected by the people for three years, and has a salary of L.374 and fees. The legislature consists of a senate, elected for three years, composed of one member from each county; and a house of representatives, composed of sixty members, annually elected. The judiciary consists of a supreme court, composed of a chief and six associate justices, who are appointed for a period of seven years by the governor, with the consent of the senate. There are also a court of errors and appeals, consisting of a chancellor, the judges of the supreme court; and six others, appointed in the same way for six years; a court of chancery, over which the chancellor presides; circuit-courts, and courts of oyer and terminer, held thrice a year in each county by the judges of the supreme court; and courts of common pleas. New Jersey sends five members to the House of Representatives of the United States. The public revenue for 1856 was L.37,804, and the expenditure for the same year L.37,506.

Religion, education, &c.

The number of churches in the state in 1850 was 807, of which 107 belonged to Baptists, 66 to the Dutch Reformed Church, 51 to the Episcopalians, 52 to the Quakers, 312 to the Methodists, 146 to the Presbyterians, and 21 to the Roman Catholics. The proportion of churches to the whole population is 1 to every 606 inhabitants. The whole value of church property in the same year was L.737,588. The educational establishments of the state consist of 3 colleges, having in all 72 professors, 460 students, and 33,000 volumes in their libraries; theological seminaries of the Presbyterian and Dutch Reformed Churches; besides numerous lower schools, at which, in 1856, 125,035 out of 176,350 children between 3 and 18 were educated. The whole number of teachers in the same year was 1942; and the total amount of funds raised for purposes of education was L.107,132. The principal benevolent institution of New Jersey is the state lunatic asylum, at Trenton, containing 233 patients in 1856. There is also, at the same place, a state prison.

History.

The earliest settlements in this country were made by the Dutch, not long after their arrival in New York, between 1614 and 1624. These were planted in the east of the district, between the Hudson and Delaware; the whole of which was claimed by the Dutch, although the Swedes had made some settlement in the western part of the same country. These claims were, however, disregarded by the British; for, in 1664, Charles II. granted to the Duke of York the whole of this country, and in the same year the duke sold it to Lord Berkeley and Sir George Carteret, in honour of the latter of whom, a native of Jersey, it received the name which it still bears. The Dutch again got possession of it in 1673, but resigned it on the conclusion of peace in the following year. New Jersey escaped the inroads of the savage tribes which desolated and afflicted most of the older colonies; but, in the war of the Revolution, it was the scene of several victories gained by the Americans, in most of which Washington was present. Among these were the battle of Princeton in 1776, and that of Monmouth in 1778. The state is divided into 20 counties; and had in 1850 a population of 489,555.

Newmarket || New Orleans.

NEWMARKET, a market-town of England, partly in the county of Cambridge, and partly in that of Suffolk, is pleasantly situated at the foot, and on the gently sloping side of a valley, 13 miles E. by N. of Cambridge, and 61 N. by E. of London. There is one principal street, about three quarters of a mile long, only partially paved, but lined with good houses, most of them modern, and many very handsome. It has a market-house, two parish churches, one of which is a fine building, Independent and Methodist churches, a national and other schools, and a savings-bank. Malt and beer are the chief manufactures. The principal importance of Newmarket, however, is derived from horse-racing, for which it is the most famous place in the country. The race-course is about 3 miles to the west of the town, and is between 4 and 5 miles in length. There is also a training ground on the slope of a hill to the south of Newmarket, and the town contains no less than fifteen training establishments for horses. Races seem to have been established here as early as the end of the sixteenth century; and soon afterwards, in the reign of James I., they became a fashionable amusement. A house was erected at Newmarket for the accommodation of that monarch, which was destroyed during the civil war, and restored in the time of Charles II. Part of it still remains, but the rest has been pulled down. Seven races are held during the year, which attract a large number of visitors. Pop. (1851) 3356.

NEW ORKNEY, a group of islands in the South Atlantic Ocean, lying between 60. and 61. S. Lat., about 675 miles S.E. of Cape Horn. The principal island is called Mainland or Pomona, and another, called Saddle Island, has a lofty mountain, known by the name of Noble's Peak, which is visible from a distance of nearly 70 miles. The islands are all covered with high and rugged hills; and there are found here large numbers of seals, and immense flocks of sea-fowl. This group forms a part of New South Shetland.

NEW ORLEANS, the commercial metropolis of Louisiana, and of the south-western states of the American Union, is situated on the left bank of the Mississippi River, at a distance, by the windings of the river, of about 100 miles from its mouth; Lat. 29. 58. N., Long. 90. 7. W. The position being one of commanding commercial importance, when viewed in connection with the immense area of navigable waters (the shore lines of which, including both banks, being estimated to be 35,000 miles in length) which find their outlet in this direction, the city has progressed in despite of many natural disadvantages. The country in its immediate vicinity has been reclaimed by the industry of man, and there is little or no land on the banks of the river within the state of Louisiana, with an inconsiderable exception at Baton Rouge, which would not be covered by the waters of the Mississippi during a considerable portion of the year, were it not for the artificial embankment which, at vast labour and expense, has been erected. This embankment or *levee* is 15 feet above low-water mark at New Orleans, or 6 feet above the level of the city, towards which it slopes almost imperceptibly, form-

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ing a crescent-shaped quay, several miles in length, which has scarcely a parallel in any part of the world for the advantages it affords for the landing and shipment of produce. Along this line for 6 or 7 miles, during the season of active business, may be seen dense forests of masts of vessels of every nation moored three or four deep.

Public buildings, &c.

The city was originally laid out regularly in the form of a parallelogram, with a front of about half a mile on the river; but in its subsequent progress the same regularity has not been observed. In the modern portions, however, including the chief business parts, and what, until very lately, was known as Lafayette, the streets are generally wide, and the buildings large and commodious, displaying much taste and elegance. Within a few years numerous blocks of buildings for stores, four to six storeys in height, have been erected; and private residences, in the upper portions of the city and in the suburbs, are every day advancing in number and style. Airy verandahs, large and beautiful gardens, groves of ornamental trees, among which the orange and the lemon scatter their fragrance and exhibit their mellowed fruit, and the magnolia spreads its luxuriant shades, adorn and beautify the town. There are many spacious public squares, laid out with taste, and shaded with beautiful trees. In one of these, originally known as the Place D'Armes, but now changed to Jackson Square, shrubbery and flowers abound; vases, statuettes, and busts crown the walks; and, in the centre, a bronze equestrian statue of the hero of New Orleans, the work of an American artist, rises to great height. Among the public buildings, the New Custom-House is most notable. It has been in course of construction about ten years, and will not be completed for two or three years more. It will cover an area greater than that of any public building in America, except perhaps the Federal Capitol, and will cost several millions of dollars. Among the finest buildings in the city are the Municipal Hall, Odd Fellows' Hall, Merchant Exchange, United States' Branch Mint, Charity Hospital, Mechanics' Institute, New School of Medicine, University Buildings, New Marine Hospital, and Widows' Home; the St Charles and St Louis Hotels, City Hotel, banks, and Arcade; and among the churches, the Cathedral, St Patrick's, the Presbyterian church in Lafayette Square, the Episcopal in Canal Street, and the Independent in Camp Street. The numerous cotton-presses and markets are also on the largest scale, possessing no inconsiderable interest. The St Charles' Hotel is one of the most imposing structures in America, and has been lately rebuilt upon the site of a similar building destroyed by fire. It is capable of accommodating 800 to 1000 guests, and is said to have been built at an expense of about L.100,000. The public cemeteries are embellished and adorned in a style peculiar to the city.

Education, religion, &c.

The educational statistics of New Orleans show a larger proportion of children at the public schools than either Cincinnati, Baltimore, or New York. The system has been some years in operation, and is highly honourable to the city. Upwards of L.40,000 are annually expended upon the public schools, and about 10,000 children are taught. The private schools are not so numerous as in other cities, and the means of acquiring an academical education are much circumscribed. A university has been located at New Orleans, with law, medical, and collegiate departments. The medical college has been in existence since 1835, and has matriculated over 2000 students, the number being, in 1856, 200. The law school was organized in 1847, and has an average of forty to fifty students. In the collegiate department little has yet been accomplished, there being no sufficient organization or endowment. A chair of commerce, founded by a merchant of New Orleans (Maunsel White), is a somewhat novel feature introduced into this university. The subject of this university is again before the legislature of the state, and it is thought that efficient improvement will be the result. A new medical school, established during the last year, affords much promise of excellence, and numbers many students. The medical student has free and constant access to all the hospitals. Of these the Charity Hospital is the chief, and is the largest institution of the kind in America, and perhaps the most efficiently regulated. It is an immense building, admirably arranged and ventilated, with handsome grounds, and accommodation for 1000 patients at one time. Among the other hospitals are the Naval, on the opposite bank of the river, Stone's, the Franklin Infirmary, and a new military hospital in course of construction.

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There are at New Orleans an academy of sciences, which meets regularly for discussion and reports; a lyceum connected with the public schools, where lectures and addresses from distinguished men are frequently delivered; and, connected with these schools, a library of 10,000 volumes, well selected, in all departments of literature and science. A free public library attached to the Mechanics' Institute was lately destroyed by fire. Newspapers are published in the French, Spanish, and German languages, as well as in English. Two monthly medical journals, of established reputation, are published; and De Bow's *Monthly Review*, a periodical devoted to the exposition of the industry of the southern and western states.

By the census of 1850 (but there have been many changes for the better since that time), it appeared there were 13 Roman Catholic, 1 Episcopal, 2 German Reformed, 1 Jewish, 5 Methodist, 4 Presbyterian, 1 Universalist, 1 Christian, and 2 other churches, with accommodation for 27,350 persons, or 23 per cent. of the population (Boston being capable of accommodating 56 per cent., and Charleston 67 per cent.). Total value of church property L.323,703, which is now swelled to about L.400,000.

Manufactures.

In proportion to population and wealth, there is no city in America which produces so few manufactures as New Orleans. With the exception of a few foundries and machine shops, no efforts in establishing factories on a large scale have been successful. This is owing to the cost of labour, the climate, and (as much as to either) a deficiency of capital. In 1850 the capital invested in manufactures was reported at L.618,675; hands employed, 3134; product, L.931,422. Nine schooners and ten steamers were built in Louisiana in 1856, of which nearly all were at New Orleans.

Commerce.

It is the commerce of New Orleans which gives to the city its distinctive character, and extends its reputation throughout the world. This commerce has been gradually extending from the humblest beginnings; and so admirable is its position in this respect that, vast as is the present trade, it must continue to grow with the development and settlement of the great interior basin of which it is the mart. Railroads and canals may divert, as they are now diverting, large portions of her trade to the markets of the eastern states; but there will be left sufficient at all times to follow the *natural* channels, and add to the commercial opulence of New Orleans. Already is the city active in giving aid to such internal improvement schemes as will counteract the strokes of her enterprising rivals; and, in a few years she has appropriated many millions of dollars for this purpose.

At the time of the transfer of New Orleans to the Americans in 1803, its commerce was very inconsiderable. In 1817, 137,746 tons entered or cleared from New Orleans; and there also arrived in the year 1500 flat-bottomed boats and 500 barges. The exports were L.2,812,713; while in 1856 they amounted to L.30,053,346. The imports through the custom-house, for the fiscal year ending 30th June 1856, amounted in value to L.3,579,856. In the year ending 31st June 1856, the foreign exports of New Orleans reached L.16,786,798; being larger than those of any American port except New York, and being about

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one-fourth of the whole exports of the Union. Excluding coin and bullion, New Orleans exports more largely of domestic goods than New York. The amount of cotton received at New Orleans, in the year 1855–6, amounted to 1,759,293 bales, or one-half of the whole crops of the United States, and was valued at L.14,660,772. In 1856 the total tonnage which entered and cleared at New Orleans was 1,436,299. The total arrivals,—ships, 874; barks, 375; brigs, 261; schooners, 399; steamers, 234; total, 2143: besides steam-boats, 2956. In 1854 there were 5 banks in New Orleans, with a capital of L.3,306,348; 3 free banks, with a capital of L.560,157; and 2 other banks in liquidation. In 1856 the banking capital of New Orleans had not increased, and is believed to be inadequate to the wants of its commerce. Under the general banking law lately adopted it is believed there will be an amelioration.

History and population.

New Orleans was founded in 1717 by Bienville, the governor of the province of Louisiana under the French. In 1769 the colony was transferred to Spain. Its population in 1785 reached 4780. Napoleon I. obtained it from Spain, and sold it to America in 1803, after it had been for many years the centre of intrigues and negotiations. On January 8, 1815, was fought the battle of New Orleans, a few miles below the city, between General Jackson, at the head of the American forces, and the British under General Pakenham, ending in the defeat of the latter with a loss in killed and wounded of nearly 3000 men. The American loss was but 13. The laws, manners, and institutions, of the French and Spanish inhabitants of New Orleans are blended happily with those of the American, and all distinctions and prejudices are being gradually obliterated. The population in 1788 reached 5331; in 1797, 8056; in 1810, 17,240; in 1820, 27,176; in 1830, 46,310; in 1840, 102,193; in 1850, 116,375; in 1856, about 125,000. Of the total population of 1850, 59,312 were white males, and 44,431 white females; 4104 free coloured males, and 6196 free coloured females; and 8012 male, and 11,595 female slaves. Of the same population (excluding slaves) 50,470 were born in foreign countries, and only 48,601 were born in the United States. (J. D. B. D^{e} B.)

NEWPORT, a municipal and parliamentary borough and market-town of England, county of Hants, in the Isle of Wight, on the left bank of the Medina, 18 miles S.S.E. of Southampton, and 82 S.S.W. of London. It is a neat well kept town, with good houses, chiefly built of brick, and has five principal streets, extending from E. to W., and several others crossing them at right angles. The parish church is a large and plain building, built in 1172, but frequently since then repaired and altered, though now in a somewhat dilapidated condition. In it was found in 1793 the coffin of the Princess Elizabeth, daughter of Charles I., who died at Carisbrook Castle, shortly after her father's execution. Newport has besides a modern Episcopal church, with an embattled tower; and Baptist, Independent, Wesleyan, Unitarian, Roman Catholic, and other churches. There are a handsome town-hall and market-house; a theatre; jail; grammar-school, founded in 1619, and remarkable as the scene of a conference between Charles I. and the Parliamentary Commissioners; several other schools; a public library, occupying one of the best buildings of the town; almshouses; and an infirmary. The industry of the town is chiefly employed in the making of lace, in which about 300 hands are engaged, and in the manufacture of implements of agriculture. For the latter of these Newport is widely famed. The market of Newport, which is held on Saturday, attracts a large number of persons from all parts of the Isle of Wight; and the corn and other produce of the island are exported from this town; while coal, provisions, and manufactured goods are imported. The River Medina, here crossed by a bridge, is navigable for small vessels as far as the town, which the tide nearly reaches. There is a quay in front of the town for the accommodation of ships. In the neighbourhood of Newport there are some beautiful walks; and a fine view of the surrounding country may be obtained from a hill, called Mountjoy, to the S. of the town. The borough returns two members to the House of Commons. Pop. parliamentary borough (1851), 8047.

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NEWPORT, a municipal and parliamentary borough and market-town of England, in the county of Monmouth, is situated on the right bank of the River Usk, which is here crossed by a fine stone bridge about 5 miles above its mouth, and 20 miles S.W. of Monmouth. The older parts are irregularly built, but other parts of it are of modern construction and of elegant appearance, and there are a number of handsome buildings. The parish church of St Woollos is an edifice in the Norman style, of which the nave and western archway are still well preserved in their original form; while the aisles are not older than the middle of the fifteenth century. Newport has two other Episcopal, besides Wesleyan and Calvinistic Methodist, Independent, Roman Catholic, and Baptist churches; several schools; an athenæum; a mechanics' institute; a working-man's institute; a dispensary; and a savings-bank. The town-hall and the post-office are handsome buildings, which have been recently erected. Ship-building is carried on to a great extent here; and there are also several iron foundries, a large nail-work, manufactories of anchors, chain-cables, &c. Newport has a spacious dock, which is able at all times to admit vessels of any size. The number of vessels registered as belonging to the port in 1856 was 92, and their tonnage 16,280. During the year 1856 there entered the port:—In the coasting trade, 1544 sailing vessels, tonnage 86,246; and 468 steamers, tonnage 34,298: in the colonial trade, 70 sailing vessels, tonnage 17,040; and 1 steamer, tonnage 602: in the foreign trade, 461 sailing vessels, tonnage 96,334; and 2 steamers, tonnage 1200—in all, 2075 sailing vessels, tonnage 199,620; and 471 steamers, tonnage 36,000. In the same year there cleared:—In the coasting trade, 6777 sailing vessels, tonnage 414,002; and 269 steamers, tonnage 17,259: in the colonial trade, 151 sailing vessels, tonnage 39,019: in the foreign trade, 898 sailing vessels, tonnage 183,440; and 5 steamers, tonnage 2828—in all, 7826 sailing vessels, tonnage 636,461; and 274 steamers, tonnage 20,087. Thus the total number of vessels entered in that year was 2546, tonnage 135,620; of those that cleared the number was 8100, and the tonnage 656,548. The town is connected with Gloucester, Cardiff, and Pontypool by railway, and with the last of these places also by the Monmouthshire Canal, which facilitates the intercourse with the neighbouring country. The trade of Newport is very extensive; the chief exports being coal, iron, and tin; while timber, provisions, and other articles are imported from America. The principal market-day is Saturday, and there are several annual fairs. Of the Castle of Newport, which is supposed to have been built by the Earl of Gloucester, a son of Henry I., only a square tower and a part of the great hall now remain, and are at present employed as a brewery. Newport was attacked in 1839 by a body of Chartists under John Frost; but the ringleaders were afterwards convicted of treason, though the punishment was commuted to transportation. The borough unites with Monmouth in sending a member to Parliament. Pop. parliamentary borough (1851), 19,842.

NEWPORT, a municipal borough and market-town of England, county of Salop, on the borders of Staffordshire, 16 miles E.N.E. of Shrewsbury, and 142 N.W. of London. It is a small town, and has a parish church, part of which is of the fifteenth century, and which would be very beautiful in the interior were it not for the brick side aisles which have been added in more recent times. There are also Roman Catholic and Independent churches, two free schools, two sets of almshouses, and a savings-bank. The

Newport ‖ Newport-Pagnell.

only manufacture carried on here is that of stockings. Pop. (1851) 2906.

NEWPORT, or *Newport-Tip*, a market-town of Ireland in the county of Tipperary, 11 miles N.N.E. of Limerick; has a parish church, a Roman Catholic church, a national school, and infantry barracks. Pop. (1851) 1114.

NEWPORT, a seaport of the United States of North America, in the state of Rhode Island, is beautifully situated on the slope of a hill on the W. side of the island, 28 miles S. by E. of Providence. It is well built; and has recently been considerably improved in this respect. The principal buildings are—the state house, a brick edifice, having an octagonal cupola, and containing accommodation for the state legislature and courts of law; a library and athenæum; a custom-house; a market-house; a masonic hall; an armoury; 15 churches of various denominations; and numerous fine hotels. Previously to the American Revolution, Newport was of great importance as a commercial city, and rivalled in that respect those of New York and Boston; but it suffered greatly during the war that followed that event; and, at its close, the population was reduced from 10,000 to 5500. The vessels belonging to the port in 1852 had an aggregate tonnage of 11,000 enrolled and licensed; of which 1851 tons were employed in the whale fishery, 3785 in the coasting trade, 560 in cod and mackerel fishing, and 255 in steam navigation. The vessels that entered in that year were 28, and their tonnage 4863; those that cleared were 20, and their tonnage 4337. The town has 7 banks, with an aggregate capital of L.130,000, and a savings-institution, whose deposits amount to L.60,791. There are also several woollen and cotton factories, and 5 newspaper offices, in the town. The assessed value of taxable property is about L.1,000,000. Newport, on account of its beautiful situation and mild climate, is a favourite summer resort, especially for visitors from the south. There is here a curious ancient structure of unknown origin, and equally mysterious in the purpose for which it was designed. It is a round building, 28½ feet high, and 23½ in diameter; and, in its lower part, it has 8 pillars about 10 feet in height. The walls are about 18 inches thick, and are pierced by 3 small loopholes. There is also a fireplace and chimney; but the roof and floors have disappeared. Some have supposed this to be a religious edifice, built by the Northmen; and others that the original settlers used it as a place of defence against the Indians: but these are mere conjectures, and no certain knowledge can be obtained about its origin or use. Pop. (1850) 9563; (1853) about 10,000.

NEWPORT, a seaport of Wales, in the county of Pembroke, on the slope of a hill near the mouth of the Nevern, 7 miles E.N.E. of Fishguard. The streets are mean and irregular; and the whole place has a very decayed appearance. In the neighbourhood there are some Druidical remains; and the town has the ruins of an old castle, built by the Normans in the thirteenth century, but afterwards destroyed by Llewelyn. Newport has an old parish church, and others belonging to Baptists, Independents, and Methodists, as well as several schools. Limekilns, malt-houses, carding and flour mills are in operation; and, by means of the harbour, which is secure, the export of slates, and the import of coal, timber, &c., is carried on. Pop. (1851) 1716.

NEWPORT-PAGNELL, a market-town of England, county of Buckingham, is situated near the confluence of the Ouse and Ousel, 48 miles N.N.W. of London. The latter river divides the town into two parts, and is crossed by an iron bridge, built in 1810. The parish church is a large ancient building, with a square tower and pinnacles. There are also Baptist, Independent, and Methodist churches; several schools; almshouses; a circulating library; and a savings-bank. The only manufacture here is that of lace, and even that is not so largely carried on as formerly; but there is some trade in corn, coal, and timber. Pop. (1851) 3312.

Newry ‖ New South Wales.

NEWRY, a parliamentary burgh and seaport of Ireland, on the borders of the counties of Down and Armagh, is beautifully situated in the valley traversed by the river of the same name, not far from its mouth in Carlingford Bay, 32 miles S.S.W. of Belfast, and 63 N. of Dublin. It consists of a fine square, and several good and well-paved streets lined with well-built and handsome houses chiefly of brick. The parish church is a fine modern building of early English architecture, with a tower and spire 190 feet high. There are also Presbyterian, Independent, Methodist, and Roman Catholic churches; a town-hall, court-house, two jails, custom-house, infantry barracks, assembly-room, fever hospital, dispensary, and workhouse. The manufactures are extensive, consisting of beer, brandy, leather, linen, cordage, cotton, glass, iron, brass, coaches, &c. The trade of the place is also considerable, especially in the export of butter, eggs, provisions, and cattle, and the import of coals, iron, &c. The river, which is here crossed by four stone bridges, admits vessels of 600 tons burden up to the town, and those of 1000 tons to within 6 miles of it. There is also a ship-canal leading to the sea, and a boat-canal to Lough Neagh, which is 32 miles distant. The number of ships registered at the port, 31st December 1856, was 114, and their tonnage 6648. In that year there entered the port coastwise, 793 sailing vessels, tonnage 47,495; and 254 steamers, tonnage 42,115. From the colonies, 16 sailing vessels, tonnage 7306; from foreign parts, 15 sailing vessels, tonnage 2535—in all, 824 sailing vessels, tonnage 57,336; and 254 steamers, tonnage 42,115. In the same year there cleared, coastwise, 278 sailing vessels, tonnage 15,111; and 250 steamers, tonnage 42,945: for the colonies, 5 sailing vessels, tonnage 2401: for foreign parts, 4 sailing vessels, tonnage 1962—in all, 287 sailing vessels, tonnage 19,474; and 250 steamers, tonnage 42,945. Steamers ply regularly twice a-week between this town and Liverpool, a distance of 153 miles. Newry is a place of great antiquity, and a Cistercian abbey was founded here in 1157 by Maurice M'Loughlin, king of Ireland. The name of the town is supposed to have been derived from the number of yew-trees which grew here, and two especially within the limits of the abbey which was called in Irish *Na yar* ("of the yew-trees"). After the Reformation, the abbey was granted to Sir Nicholas Bagnal, marshal of Ireland, who converted it into a dwelling-house, erected a church and castle, and rebuilt the town. Newry formerly sent two members to the Irish, and now sends one to the imperial Parliament. Pop. 1851) 13,191.

NEW SOUTH SHETLAND, a group of islands in the Antarctic Ocean, lying between S. Lat. 60. 32. and 67. 13., and W. Long. 44. 53. and 68. 15.; about 600 miles S.S.E. of Cape Horn. They are twelve in number, and extend for a distance of 300 miles from N.N.E. to S.S.W., being bounded on the S. by a broad strait called Bransfield Strait, separating them from an extensive country which apparently lies near the S. pole. The islands are rocky and mountainous, having some peaks between 6000 and 7000 feet high. They are covered with snow for nearly the whole year, and the only vegetation that is found in these desolate regions consists of lichens and mosses, and some scanty grass, which appear in a few tracts of the islands in the warmest time of the year. They are of volcanic formation, and some of the mountains are covered with scoriæ and lava; while hot springs have been discovered rising from among the snow with a temperature of not less than 146°. The only animals that are found on these islands are sea-fowls, of which the albatross, the penguin, and the sea-cormorant are the principal. Whales and seals of different kinds are found in the seas; and the islands are frequently visited for the purpose of taking these animals. New South Shetland was discovered in 1819 by Captain Smith.

NEW SOUTH WALES. See AUSTRALIA.

NEWSPAPERS.

Newspapers.

In popular language the term "NEWSPAPERS" has a more restricted application than is given to it in the language of the law. Its use is confined, or almost confined, to such periodical publications as contain more or less of political intelligence, published at short intervals; whilst in the phraseology of the British statutes and law-books the word "Newspaper" is defined to include —(1.) "Any paper containing public news, intelligence, or occurrences, printed in any part of the United Kingdom, to be dispersed and made public;" (2.) Any paper, printed at intervals, not exceeding twenty-six days, of which advertisements are the sole or principal contents; and (3.) "Any paper containing any public news, intelligence, or occurrences, or any remarks or observations thereon, printed in any part of the United Kingdom for sale, and published periodically, or in parts or numbers, at intervals not exceeding twenty-six days between the publication of any two such papers" (provided such paper shall not exceed in dimensions and bulk two sheets of paper, each twenty-one inches in length, by seventeen inches in breadth; and provided also that such paper shall be published for sale for a less sum than sixpence). These definitions and provisos were enacted with reference to duties which have since been repealed, but they have still the force of law, although within smaller limits. And to this cause it is owing that publications, which none of their readers would speak of as "newspapers," still continue to bear that designation in the official returns of the Stamp-Office and the Post-Office.

Legal definition of a newspaper.

The elaborate machinery, the wide circulation, and the vast influence of newspapers, are now such familiar things, that it needs some mental effort to conceive of their absence, without an undue depreciation of the public opinion of the days when newspapers were unknown. It is even difficult thoroughly to apprehend the facts that those days are little more than two centuries removed from us, and that the newspaper of a period considerably less distant than one century, was utterly unlike any publication that now bears the name. A few men, indeed, of high principle and vigorous intellect,—of some of whom we shall have to speak hereafter,—earlier employed themselves in political writings, which were periodically issued; but those writers were rather pamphleteers than journalists. The true predecessors of the broad-sheets of our own day were for the most part little better than court newsmen, slenderly endowed even as respects syntax and orthography, who were usually content to retail meagre intelligence in disjointed paragraphs, without a syllable of useful comment or intelligible inference; and of whom not a few were in the habit of filling up occasional blanks by the insertion of false news on one day, and the contradiction of it on another. In this article it will be our aim to indicate, however briefly, the successive steps by which publications of such a class have been transformed into what even statesmen are accustomed to honour with the name of a "fourth estate" of the realm; to show in what manner the legislation affecting newspapers has been gradually amended in Great Britain, though by no means at an equal pace with the improvement of the press itself, and that this amendment of British law is pregnant with instruction for other countries; and, finally, to sketch, as far as our needful limits will permit, the growth and present statistics of newspapers in the principal countries of continental Europe, as well as in the United States of America.

Contrasted character of the newspapers of the 18th and 19th centuries.

News-papers.

I.—THE NEWSPAPERS OF THE UNITED KINGDOM.

The first journalists were the writers of "news-letters." Originally the dependents of great men, each employed in keeping his own master or patron well-informed, during his absence from court, of all that transpired, the duty grew at length into a calling. The writer had his periodical subscription-list, and instead of writing a single letter, wrote as many letters as he had customers. Then one, more enterprising than the rest, established an "intelligence-office," with a staff of clerks,[1] and thus realized in sober prose Chaucer's poetical vision of *The House of Fame*:—

The early writers of news-letters.

> "When one had heard a thing, I wiss,
> He came straight to another wight,
> And 'gan him telling anon, right
> The same tale that to him was told.
> * * * * * *
> Whether the tidings were sooth or false,
> Yet would he tell it natheless,
> And ever more with more increase
> Than it was erst: Thus North and South
> Went every tiding, from mouth to mouth."

Of the earlier news-letters good examples may be seen in Sir John Fenn's collection of *Paston Letters*, and in Arthur Collins' *Letters and Memorials of State* (better known, perhaps, as the *Sydney Papers*). Of those of later date, specimens will be found in Knowler's *Letters and Dispatches of Strafford*, and in other well-known books. In the recently-published *Diary of Narcissus Luttrell*, examples of manuscript news-letters occur as late as the reign of William III.

The fiction of an English Mercury of 1588.

By the pains and critical acumen of Mr Thomas Watts, of the British Museum, the old and obstinate fiction, that "for the first printed newspaper, mankind are indebted to the wisdom of Elizabeth and the prudence of Burleigh," is at length gradually disappearing from current literature, although it has been many times repeated since the first publication of his able pamphlet. The remarkable tenacity of life which characterizes misstatements that have once gained the public ear, may still therefore make it desirable to enumerate the principal reasons which led to the conviction that the *English Mercurie* of 1588 is a forgery. As adduced by Mr Watts himself, they run thus:—(1.) The obvious resemblance of the type to Caslon's "English fount" of the middle of the eighteenth century. (2.) The rigid maintenance of that distinction between *u*'s and *v*'s, *i*'s and *j*'s, which was utterly unknown to the printers of the sixteenth century. (3.) The preservation of the original MSS. from which the printer worked, written in a modern hand, with modern spelling, and with corrections,—obviously those, not of a transcriber, but of an author,—which the printer has copied; these MSS. being on paper manufactured in the early part of the reign of George III.; and (4.) Serious misstatements of fact, and anachronisms of date, of a kind which could not occur in the statements of persons who had taken part in the events they profess to narrate. These

[1] *Cymbal.*—"This is the outer room where my clerks sit,
And keep their sides, the Register in the midst;
The Examiner, he sits private there, within;
And here I have my several rolls and files
Of news by the alphabet, and all put up
Under their heads."—JONSON, *The Staple of News* (acted in 1625).

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points have been thoroughly established; and it may now be hoped that the *English Mercurie* is finally relegated to its proper niche in the gallery of literary impostures.

The newspamphlets of the 16th century.

Although no genuine newspaper of the sixteenth century can be produced, English pamphlets, as well as French, Italian, and German, occur with such titles as *Newes from Spaine*, and the like. In the early years of the seventeenth they became very numerous. In 1614 we find Butler (the anatomist of Melancholy) pointing a sarcasm against the non-reading habits of "the major part," by adding, "if they read a book at any time ... 'tis an English Chronicle, St Huon of Bordeaux, Amadis de Gaul, &c., a play-book, or *some pamphlet of news*."[1] ... The most eminent purveyors of reading of this sort were Nathaniel Butter, Nicholas Bourne, and Thomas Archer; and by them was issued, in May 1622, the first authentic *periodical* newspaper which is now known to exist:[2]

The Weekly News of 1622.

—"The 23d of May—*The Weekly News from Italy, Germany*, &c., London, printed by J. D. for Nicholas Bourne and Thomas Archer." Butter's name does not occur on this number, but on many subsequent numbers it appears in connection sometimes with Bourne's and sometimes with Archer's name; so that there was probably an eventual partnership in the new undertaking. Butter had published *Newes from Spaine* in 1611, and he continued to be a publisher of news until 1641, if not later. It is to him that a passage in the fourth act of Fletcher's *Fair Maid of the Inn* obviously refers:—

... "It shall be the ghost of some lying stationer. A spirit shall look as if *butter* would not melt in his mouth; a new *Mercurius Gallo-Belgicus*."—*Act* iv., sc. 2.

In *The Certain Newes of this Present Week* [ending 23d August 1622] the publisher inserted this advertisement:—"If any gentleman or other accustomed to buy the weekly relations of newes be desirous to continue the same, let them know that the writer, or transcriber rather, of this newes hath published two former newes; the one dated the second, the other the thirteenth of August, all which do carry a like title, and have dependence one upon another; which manner of writing and printing he doth purpose to continue weekly, by God's assistance, from the best and most certain intelligence." There are on the face of these early papers many indications that they were published without legal sanction or cognisance. They touched very slightly on home news; and it is probable that for a time the censorship did not much care to interfere with their scraps of foreign intelligence. But as their numbers increased, jealousy appears to have been excited, and forced suppressions to have been imposed. One of the latest which bears Butter's name, entitled *The Continuation of the Forraine Occurrents for 5 weekes last past*, January 11, 1640 (o.s.), contains this address:—"The Printer to the Reader—Courteous reader, we had thought to have given over printing our foreign avisoes, for that the licenser (out of a partial affection) would not oftentimes let pass apparent truth, and in other things (oftentimes) so cross and alter, which made us almost weary of printing; but he being vanished, and that office fallen upon another more understanding in these forraine affaires, and as you will find more candid, we are again, by the favour of His Majesty and the State, resolved to go on printing, if we shall find the world to give a better acceptation of them than of late, by their weekly buying them." These hopeful anticipations do not appear to have been realized in the individual case of the writer; but a vast number of competitors for public support quickly presented themselves in the stirring times which England was then entering upon, and their productions were eagerly read. November 1641 is especially noticeable for the publication, in the form of a newspaper, of the earliest authentic report of the proceedings of Parliament. *Diurnal Occurrences, or the Heads of several Proceedings in both Houses of Parliament*, was usually, notwithstanding its title, a weekly periodical, and it sometimes contained ordinary news in addition to its staple matter. This was followed, within five years, by a long train of newspapers, most of which were published weekly, such as *The English Post, Ireland's True Diurnal, England's Memorable Accidents, Weekly Intelligence, The Kingdom's Weekly Intelligencer, The Spy, Mercurius Aulicus, M. Anglicus, M. Civicus, M. Rusticus, The Weekly Account, The Parliament's Scout, M. Britannicus, The Scotch Intelligencer, The Scottish Mercury, The Welch Mercury, Mercurius Cambro-Britannicus, The Kingdom's Weekly Post, Le Mercure Anglois* (in French), *The London Post, The Country Messenger*, and a multitude more. Nearly the whole of these papers are characterized by clumsiness of arrangement, by extreme paucity of original comment on the news narrated, and very frequently by the fierce virulence of such comments as do appear. The papers of this period which stand out most saliently from the rest are, the *Mercurius Britannicus, M. Pragmaticus*, and *M. Politicus* of Marchmont Nedham; and the *Mercurius Aulicus* of John Birkenhead. Nedham was unquestionably both the ablest and the readiest man that had yet tried his hand at a newspaper. He commenced *Britannicus* on the 22d August 1643, zealously advocated in it the cause of the Parliament, and continued its publication until 1647. At that period he changed sides for a time, under circumstances of which we know nothing, save from the reports of his enemies. According to them, "obtaining the favour of a known royalist to introduce him into His Majesty's presence at Hampton Court, ann. 1647, he then and there knelt before him, and desired forgiveness for what he had written against himself and his cause; .... and soon after wrote *Mercurius Pragmaticus*, which, being very witty, satirical against the Presbyterians, and full of loyalty, made him known to, and admired by, the bravadoes and wits of those times. .... At length ... Lenthall and Bradshaw ... persuaded him to change his style once more [in favour of] the Independents, then carrying all before them. So that, being bought over, he wrote *Mercurius Politicus*, so extreme contrary to the former, that the generality for a long time ... could not believe that that 'intelligence' could possibly be written by the same hand that wrote the *M. Pragmaticus*. .... The last [*i.e.*, the *Pragmatici*] were endeavoured by the parliamenteers to be stifled, but the former, the *Politici*, which came out by authority, and flew every week into all parts of the nation for more than ten years, had very great influence. .... He was then the Goliah of the Philistines, the great champion of the late usurper, whose pen, in comparison of others, was like a weaver's beam."[3] Birkenhead's *M. Aulicus* was also begun in 1643, and con-

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Rapid multiplication of newspapers during the civil wars.

Newspapers written by Marchmont Nedham,

and by Sir J. Birkenhead.

[1] So Crabbe, writing in similar strain a hundred and seventy years later:—

"To you all readers turn, and they can look
Pleased on a paper who abhor a book;
Those who ne'er deigned their Bible to peruse,
Would think it hard to be denied their news."—*The Newspaper*, 1785.

[2] The *Courant, or Weekly Newes from Foreign Parts*, of Oct. 9, 1621, mentioned by Nichols (*Literary Anecdotes*, iv. 38), is of doubtful authenticity. It is described as "a half-sheet in the black letter, 4to, out of High Dutch, printed for Nath. Butter." Yet it is probable that future researches will discover papers, serially published, of even earlier date. Publications of this sort have been usually too little cared for in our great libraries.

[3] Wood, *Athenæ Oxonienses* (by Bliss), iii. 1182. A new *Mercurius Britannicus* appeared in June 1647, but did not long continue. Another, entitled *M. Britannicus again Alive*, was published in May 1648, and the title was often subsequently revived.

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tinued, although irregularly, until nearly the close of the civil war. According to Wood, Charles I. "appointed him to write the *Mercurii Aulici*, which being very pleasing to the loyal party, His Majesty recommended him to the [University] electors that they would choose him moral philosophy reader;" which was done accordingly. He was assisted in the composition of *Aulicus* by George Digby and by Dr Peter Heylin. He had considerable powers of satire after a coarse fashion, and was one of the few rough-weather royalists who were permitted to bask in the sunshine of the Restoration.

Under Cromwell, the chief papers were *M. Politicus* and *The Public Intelligencer* (of which the first number appeared on the 8th October 1655). These publications were issued on different days of the week, and at length they became conjointly the foundation of our present *London Gazette*. Even at their origin they were in some degree official papers. The *Intelligencer* underwent several modifications of title at various periods, and was for a time edited by Nedham. In 1659 the Council of State caused the following announcement to be published:—"Whereas Marchmont Nedham, the author of the weekly news-books, called *Mercurius Politicus*, and *The Publique Intelligencer*, is, by order of the Council of State, discharged from writing or publishing any publique intelligence; the reader is desired to take notice that, by order of the said council, Giles Dury and Henry Muddiman are authorized henceforth to write and publish the said intelligence, the one upon the Thursday and the other upon the Monday, which they do intend to set out under the titles of *The Parliamentary Intelligencer*, and of *Mercurius Publicus*." After the Restoration, a monopoly of newspapers was attempted to be set up in favour of Roger L'Estrange, by a royal grant of "all the sole privilege of writing, printing, and publishing all narratives, advertisements, mercuries, intelligencers, diurnals, and other books of public intelligence; . . . with power to search for and seize unlicensed and treasonable, schismatical and scandalous books and papers." L'Estrange continued the papers above mentioned, but changed their titles to *The Intelligencer* and *The News*. In the first number of the former he paints both himself and his epoch in unmistakeable colours:—"Supposing the press in order," he says, "the people in their right wits, and news or no news to be the question, a public Mercury should never have my vote; because I think it makes the public too familiar with the actions and counsels of their superiors, too pragmatical and censorious, and gives them not only an itch, but a kind of colourable right and license to be meddling with the government." But then, he bethinks him, that in some shape or other the government is sure to be attacked; and therefore ends thus:—"So that, upon the main, I perceive the thing requisite; and (for ought I can see yet) once a week may do the business; for I intend to utter my news by weight, not by measure. . . . The way as to the vent that has been found most beneficial to the master of the book, has been to cry and expose it about the streets, by Mercuries and hawkers, but whether that way may be so advisable in some other respects may be a question." But not even in that day was such a scheme workable. L'Estrange's papers continued only until 1665, and within that short period had their competitors, though of a miserable kind. The first number of *The Oxford Gazette* was published (whilst the court was at Oxford, on account of the great plague then raging in London) on the 14th November 1665, and became *The London Gazette* with the twenty-fourth number, issued on the 5th February 1666. For a very long period it retained its original size of a single leaf in small folio. It contained no news or documents but such as were palatable to the court; and these were retailed in the most meagre fashion, without a *scintilla* of literary ability. After the Revolution, however, it shared, to some small extent, in the general improvement of the press; and has now been published twice a week, without interruption, and in a continuous and uniform series, for nearly two centuries.

The newspapers of the Restoration.

Establishment of the London Gazette.

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The excitement which attended the "Popish plot," and the "Exclusion Bill," largely increased the number of newspapers, without much elevating their character. The increase led to a new "Proclamation for suppressing the printing and publishing unlicensed news-books and pamphlets of news" (May 12, 1680), in which it is set forth that, "of late, many evil-disposed persons have made it a common practice to print and publish pamphlets of news, without license or authority, and therein have vended . . . idle and malicious reports," &c. Great efforts were made to give effect to this proclamation by the infliction of punishments of atrocious severity; but when English printers were terrified into submission, Dutch printers supplied their places. News-pamphlets poured in from Holland in spite of the utmost efforts of licensers and custom-house officers, and helped to prepare the way for the downfall of the Stuarts.

Restrictions on the newspaper press in 1680.

A few incidental paragraphs and announcements may deserve to be culled from the London newspapers of this period, by way of a small sample of their quality. In the fiftieth number of *Domestick Intelligence, or News both from City and Country* (9th July, 1679), we read:—"Whereas, on Thursday the 18th instant, in the evening, Mr John Dryden was assaulted and wounded in Rose Street, in Covent Garden, by divers men unknown: if any person shall make discovery of the offenders to the said Mr Dryden, or to any justice of peace, ... he shall not only receive fifty pounds, ... but if the discoverer be himself one of the actors, he shall have the fifty pounds without letting his name be known, or receiving the least trouble by any prosecution." [In the present day such an advertisement as this would entail a fine of fifty pounds on the newspaper in which it appeared.] In No. 37 of *The True News* (27th March, 1680), it is announced that a project is set on foot "for conveying of letters, notes, messages, amorous billets, and all bundles whatsoever under a pound weight, and all sorts of writings (challenges only excepted), to and from any part of the city and suburbs; to which purpose the projectors have taken a house in Lime Street for a general office, and have appointed eight more stages in other parts at a convenient distance; *a plot which, if not timely prevented by the freemen porters of the city, is like to prove the utter subversion of them and their worshipful corporation.*" *The London Gazette* of the 3d December 1683 informs its readers that "there is a considerable sum of money already paid in to Mr Child at Temple Bar, towards the lottery of the jewels of his late R.H. Prince Rupert. For the satisfaction of all such as have any doubts of the fair and equal proceeding in the drawing thereof, ... His Majesty will be pleased publicly, in the banqueting-house, to see the blanks told over, ... and to read the papers in which the prizes are to be written, which . . . . His Majesty will mix amongst the blanks." In this instance, it will be noticed, the style of the gazetteer is sufficiently prolix to necessitate abridgment, but usually it is of the concisest. Deeds which still sound in our ears like a trumpet are narrated in the same bald manner as are the merest trivialities of the court. Thus, No. 1884 ends with this paragraph:—"This day Algernon Sidney, Esq., was brought from the Tower to the place appointed for his execution on Tower Hill, where he was beheaded on a scaffold erected for that purpose;" and No. 1886 with the following:—"On Monday last, His Majesty and Her Royal Highness were pleased to do Sir William Jennens the honour to see his new-erected bagnio in Longacre, and very well to approve thereof."

Specimen of newspapers of the closing years of Charles II.

The very day which followed the abdication of James II. was marked by the appearance of three newspapers—*The*

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Universal Intelligence, *The English Courant*, and *The London Courant*. Within a few days more, these were followed by *The London Mercury*, *The Orange Gazette*, *The London Intelligence*, *The Harlem Currant*, and others. The Licensing Act, which was in force at the date of the Revolution, expired in 1692, but was continued for a year, when it finally ceased. On the appearance of a paragraph in *The Flying Post* of 1st April 1697,[1] which appeared to the House of Commons to attack the credit of the exchequer bills, leave was given to bring in a bill "to prevent the writing, printing, or publishing of any news without license;" but the bill was thrown out in an early stage of its progress. That *Flying Post* which gave occasion to this attempt was also noticeable for a new method of printing, which it thus announced to its customers:—"If any gentleman has a mind to oblige his country friend or correspondent with this account of public affairs, he can have it for twopence . . . . on a sheet of fine paper, half of which being left blank, he may thereon write his own affairs, *or the material news of the day*."

Increase of newspapers at the Revolution of 1688.

The press under Queen Anne.

But it was in the reign of Queen Anne that the newspaper press first became really eminent for the amount of intellectual power and of versatile talent which was employed upon it. It was also in that reign that the press was first fettered by the newspaper stamp. The accession of Anne was quickly followed by the appearance of the first London daily newspaper, *The Daily Courant* (1703), published and edited by the well-known printer Samuel Buckley, and this by a crowd of new competitors for public favour of less frequent publication. The first number of one of these, *The Country Gentleman's Courant* (1706), was given away gratuitously; and the following special pretensions were put forward on its behalf:—"Among the crowd of newspapers that come out weekly, it is hoped that this may find as favourable a reception as any, when its usefulness is rightly considered; for here the reader is not only diverted with a faithful register of the most remarkable and momentary [*i.e.*, momentous] transactions at home and abroad, ... but also with a geographical description of the most material places mentioned in every article of news, whereby he is freed the trouble of looking into maps."

Defoe's Review.

Shortly after the commencement of *The Daily Courant*, Defoe began his famous paper *The Review*. At first he called it *A Weekly Review of the Affairs of France, purged from the Errors and Partiality of News-Writers and Petty Statesmen of all sides*. But this long and singular title was objected to by friends and ridiculed by foes. With the eighteenth number Defoe dropped the words "of the affairs of France," although on the title-page of his second volume he returned to the original designation thus modified:—*A Review of the Affairs of France, with Observations on Transactions at Home*. At the outset it was published weekly, afterwards twice, and at length three times a week. It continued from February 1704 to May 1713; and a complete set is of extreme rarity. From the first page to the last it is characterized by the manly boldness and persistent tenacity with which the almost unaided author utters and defends his convictions on public affairs, against a host of clever and bitter assailants. He waxed very wroth at times—as well he might—but expresses his anger much oftener by incisive sarcasm than by the coarse personalities which were then so common. The work is as much marked by genial humour as by keen insight; and if in its style it lacks polish, it undeniably abounds in vigour. Especially memorable is it as the first newspaper which bears plainly on its face that the author was far more intent on making patriots than on making money. In that corner of his paper which he entitled "Advice from the Scandalous Club," and set apart for the discussion of questions of literature and manners, and sometimes topics of a graver kind, Defoe to some extent anticipated the *Tatlers* and *Spectators* of a later day. He thus explains the purpose which he had there in view:—"As to our brethren of the worshipful company of news-writers, ... they shall meet with no ill treatment. But if they tell a lie that a man may feel with his foot, and not only proclaim their folly but their knavery; if they banter religion, sport with things sacred, and dip their pens in blasphemy; our Scandalous Club is a new corporation erected on purpose to make inquisition of such matters, and will treat them but scurvily, as they deserve." The essays of Queen Anne's day, though in their origin they partook of the character of newspapers, open a theme too wide for the scope of this article, and more properly belong to the subject of Periodical Publications.

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The year 1710 was marked by the appearance of *The Examiner, or Remarks upon Papers and Occurrences* (No. 1, August 3), of which thirteen numbers had appeared by the co-operation of Bolingbroke, Prior, Friend, and King, before it was placed under the sole control of Swift, who, as Sir W. Scott has said, "not satisfied with directing his artillery on the main body of the enemy, singled out for his aim particular and well-known individuals. Wharton, whose character laid him too open for such an attack, was the first of these victims. Sunderland, Godolphin, Cowper, Walpole, and Marlborough himself, became the butts of his satire; but he is less justifiable where it is exerted against Lord Somers, whose services to his country, independent of ancient friendship and undeniable virtues, ought to have silenced such reproaches as had no better foundation than private scandal."[2] *The Whig Examiner*, avowedly intended "to censure the writings of others, and to give all persons a re-hearing who had suffered under any unjust sentence of *The Examiner*," followed on the 1st September; and *The Medley* three weeks afterwards. In the same year a paper, entitled *The British Mercury* (No. 1, March 27), was established by the proprietors of the Sun Fire Office. In subsequently commencing a new series of this paper, its conductors prefixed a sort of summary—from their own point of view, of course—of the previous history of English newspapers. After describing the renewed activity of the press at the Revolution period, the writer proceeds:—"Such a furious itch of novelty has ever since been the epidemical distemper, that it has proved fatal to many families; the meanest of shopkeepers and handicrafts spending whole days in coffee-houses to hear news and read politicks, whilst their wives and children wanted bread at home; and their business being neglected, they were themselves at length thrust into gaols. . . . . Hence sprung that inundation of *Postmen*, *Postboys*, *Evening Posts*, *Supplements*, *Daily Courants*, *Protestant Postboys*, amounting to twenty-one every week, besides many more which have not survived to this time, and besides the *Gazette*, which has the sanction of public authority; and this *Mercury*, only intended for and delivered to those . . . . insured by the Sun Fire Office. Yet has not all this variety been sufficient to satiate the immoderate appetite of intelligence, without ransacking France, Holland, and Flanders, whence the foreign mails duly furnish us with the *Gazettes* or *Courants* of Paris, Brussels, Antwerp, Amsterdam, Hague, Rotterdam, Leyden, and some others not so common, besides the French and Holland *Gazettes-à-la-Main*."

Swift's Examiner, and its antagonists.

The British Mercury.

This increasing popularity and influence of the newspaper press could not fail to be distasteful to the ruling powers. Prosecutions were multiplied, yet with small success. At

[1] "We hear that when the exchequer notes are given out upon the Capitation Fund, whosoever shall desire specie on them will have it at 5½ per cent., of the Society of gentlemen that have subscribed to advance some hundred thousands of pounds." (See *Parliamentary History of England*, v. 1164.)

[2] *Life of Swift*, i. 130.

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length some busy brain struck out amidst its cogitations the fertile expedient of a newspaper tax. To whom the first idea was owing is not now known. All that our parliamentary history records on this point is, that "some members in the Grand Committee of Ways and Means suggested a more effectual way for suppressing libels," &c. The immediate or ostensible occasion, it may be added, of the enactment lay simply in the publication of a Dutch state-paper by the writer of the *Daily Courant*, one of the best journals of the time. The duty imposed was a halfpenny on papers of half a sheet or less, and a penny on such as ranged from half a sheet to a single sheet (10 Ann., c. xix., § 101), and it came into force on the 19th July 1712. The first results of the tax cannot be more succinctly or more vividly described than in the following characteristic passage of the *Journal to Stella*:—"Do you know that Grub Street is dead and gone last week? No more ghosts or murders now for love or money. I plied it close the last fortnight, and published at least seven papers of my own, besides some of other people's; but now every single half-sheet pays a halfpenny to the queen. The *Observator* is fallen; the *Medleys* are jumbled together with the *Flying Post*; the *Examiner* is deadly sick; the *Spectator* keeps up, and doubles its price,—I know not how long it will hold. Have you seen the *red stamp* the papers are marked with? *Methinks the stamping is worth a halfpenny.*" It is one of the "curiosities of literature" that the first commissioner of the stamp-office was Richard Steele, who did not, however, long retain the post.

Imposition of the newspaper stamp.

Swift's account of its results.

Swift's doubt as to the ability of the *Spectator* to hold out against the tax was justified by its discontinuance in the following year. But the impost which was thus fruitful in mischief, by suppressing much good literature, wholly failed in keeping out bad. Some of the worst journals that were already in existence kept their ground, and the number of such erelong increased.[1] An enumeration of the London papers of 1714 comprises *The Daily Courant*, *The Examiner*, *The British Merchant*, *The Lover*, *The Patriot*, *The Monitor*, *The Flying Post*, *The Postboy*, *Mercator*, *The Weekly Pacquet*, and *Dunton's Ghost*. Another enumeration in 1733 includes *The Daily Courant*, *The Craftsman*, *Fog's Journal*, *Mist's Journal*, *The London Journal*, *The Free Briton*, *The Grub Street Journal*, *The Weekly Register*, *The Universal Spectator*, *The Auditor*, *The Weekly Miscellany*, *The London Crier*, *Read's Journal*, *Œdipus, or The Postman Remounted*, *The St James' Post*, *The London Evening Post*, and *The London Daily Post*. Twenty years later the last-named publication became the well-known *Public Advertiser*. Nor ought it to be forgotten, that to this multiplicity of newspapers we are indebted for the foundation of that storehouse of curious information, *The Gentleman's Magazine*. The title-page of the first volume avows that it is "collected chiefly from the public papers;" and in his preface the editor remarks, that "upon calculating the number of newspapers, it is found that . . . no less than two hundred half-sheets per month are thrown from the press in London, and about as many printed elsewhere in the three kingdoms." Towards the middle of the century the provisions and the penalties of the Stamp Act were made more stringent, and the jail population largely increased by the number of offences against it. Yet the number of newspapers continued to rise. Johnson, writing in 1758, bears testimony to the still growing thirst for news:—"Journals are daily multiplied, without increase of knowledge. The tale of the morning paper is told in the evening, and the narratives of the evening are bought again in the morning. These repetitions, indeed, waste time, but they do not shorten it. The most eager peruser of news is tired before he has completed his labour; and many a man who enters the coffee-house in his night-gown and slippers, is called away to his shop or his dinner before he has well considered the state of Europe." Five years before this remark appeared in the *Idler*, the aggregate number of newspapers annually sold in England, on an average of three years, amounted to 7,411,757. In 1760 it had risen to 9,464,790, and in 1767 to 11,300,980.

List of the London papers of 1714, and in 1733.

Johnson's opinion of the newspapers of 1758.

Newspapers.

The first newspaper purporting by its title to be Scottish (*The Scotch Intelligencer*,[2] 7th September 1643), and the first newspaper actually printed in Scotland (*Mercurius Politicus*, published at Leith in October 1653), were both of English manufacture; the one being intended to communicate more particularly the affairs of Scotland to the Londoners; the other to keep Cromwell's army well acquainted with the London news. The reprinting of the *Politicus* was transferred to Edinburgh in November 1654, and it continued to appear (under the altered title, *Mercurius Publicus*, subsequently to April 1660) until the beginning of 1663. Meanwhile, an attempt by Thomas Sydserfe to establish a really Scottish newspaper, *Mercurius Caledonius*, had failed after the appearance of ten numbers, the first of which had been published at Edinburgh on the 8th of January 1661. It was not until March 1699 that a Scottish newspaper was firmly established, under the title of *The Edinburgh Gazette*, by James Watson, a printer of eminent skill in his art. Before the close of the year the *Gazette* was transferred to John Reid, by whose family it long continued to be printed. In February 1705 Watson started *The Edinburgh Courant*, of which he only published fifty-five numbers. In 1710 the town council authorized Mr Daniel Defoe to print the *Edinburgh Courant* in the place of the deceased Adam Bog. Four years earlier the indefatigable pioneer of the Scottish press, James Watson, had commenced the *Scots Courant*, which he continued to print until after the year 1718. To these papers were added, in October 1708, *The Edinburgh Flying Post*; and in August 1709, *The Scots Postman*. Five years later this paper appears to have been incorporated with the *Edinburgh Gazette*, and the conjoined publications appeared twice a week. In December 1718 the town council gave a privilege to James M'Ewan to print the *Edinburgh Evening Courant* (a journal which still subsists) three times a week, on condition that before publication he should "give ane coppie of his print to the magistrates." *The Caledonian Mercury* dates from the 28th of April 1720. At one period it was published thrice, and afterwards twice a week. Its first proprietor was William Rolland, an advocate, and its first editor Thomas Ruddiman. The property passed to Ruddiman on Rolland's death in 1729, and remained in his family until 1772. It now appears daily.

First newspapers of Scotland.

The early newspapers which in title and subject-matter are Irish, belong, like their Scottish contemporaries, to the London press. Such, for example, are *Ireland's True Diurnal* (February 1642), and *Mercurius Hibernicus* (1644). Such also was *The Irish Courant*, published almost half a century later (No. 1, April 4, 1690); but this Revolution journal had been preceded by *The Dublin News-Letter*, printed in 1685, "by Joseph Ray in College Green. for Robert Thornton, at the Leather Bottle in Skinner Row;" and was followed in 1690 by *The Dublin Intelligence* (No. 1, September 30, 1690), which was also printed

Early Irish newspapers.

[1] See the Burney collection of newspapers in the British Museum; and Nichols, *Literary Anecdotes of the Eighteenth Century*, iv. 33–97.

[2] This was followed by *The Scotch Dove*, the first number of which is dated "Sept. 30 to October 20, 1643," and by *The Scottish Mercury* (No. 1, Oct. 5, 1643). In 1648 a *Mercurius Scoticus* and a *Mercurius Caledonius* were published in London. The *Scotch Dove* was the only one of these which attained a lengthened existence.

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by Joseph Ray. *Falkener's Journal* was established in 1728, and appeared daily. *Esdaile's News-Letter* began in 1744, took the title of *Saunders' News-Letter* in 1754 (when it appeared three times a week), and became a daily newspaper in 1777. It is said still to possess the largest circulation which has ever been attained by an Irish daily paper.

Waterford possessed a newspaper as early as 1729, entitled *The Waterford Flying Post.* It professed to contain "the most material news both foreign and domestic," was printed on common writing-paper, and published twice a week at the price of a halfpenny. *The Belfast News-Letter* was started in 1737, and it still flourishes. The more famous *Freeman's Journal* was long pre-eminent amongst the Dublin papers for ability and vigour. It was established by a committee of the first society of "United Irishmen" in 1763, and its first editor was Dr Lucas. Flood and Grattan were at one time numbered amongst its contributors; although the latter, at a subsequent period, is reported to have exclaimed in his place in the Irish Parliament, "the *Freeman's Journal* is a liar, ... a public, pitiful liar."[1] The relations between the journalism and the oratory of Ireland have been not infrequently of this stormy character.

Prosecutions of the press, 1760–1820.

The history of newspapers during the long reign of George III. is a history of criminal prosecutions, in which individual writers and editors were repeatedly defeated and severely punished; whilst the press itself derived new strength from the protracted conflict, and turned ignominious penalties into signal triumphs. From the days of John Wilkes to those of Leigh Hunt, every conspicuous newspaper prosecution gave tenfold currency to the doctrines that were assailed; and if some timid malcontents were occasionally cowed into silence and retreat, the ranks were the stronger for their absence. In the earlier part of this period, men who were mere traders in politics—whose motives were obviously base, and their lives contemptible—became powers in the state, able to brave king, legislature, and law courts, by virtue of the simple truth that a free people must have a free press. Yet the policy that had utterly failed in 1763 continued to be clung to in 1819.

Rise of parliamentary reporting in the newspapers.

One of the minor incidents of the *North Briton* excitement led indirectly to valuable results with reference to the much-vexed question of parliamentary reporting. During the discussions respecting the Middlesex election, Almon the bookseller collected from members of the House of Commons some particulars of the debates, and published them in the *London Evening Post.* The success which attended these reports induced the proprietors of the *St James's Chronicle* to employ a reporter, in their turn, to collect notes in the lobby and at the coffee-houses. This repeated infraction of the "privilege" of secret legislation, entailed the memorable proceedings of the House of Commons in 1771, with their fierce debates, angry resolutions, and arbitrary imprisonments;—all resulting, at length, in that *tacit* concession of publicity of discussion which has ever since prevailed.

Chief London newspapers. 1760–1820.

The three metropolitan newspapers which at different periods of this reign stood pre-eminent amongst their competitors were *The Public Advertiser, The Morning Post,* and *The Morning Chronicle.* The far more striking predominance of *The Times* is, as we shall see hereafter, a thing of later date. The first-named paper owed some of its popularity to the letters of Junius. The *Post* and the *Chronicle* were mainly indebted for their success (in bygone days) to the personal qualities of individual editors.

It need hardly be said that the *Public Advertiser* was already a successful and rising journal when it published the first contribution of Junius. To none other would the letters of Junius have been sent. Many of them had appeared before the smallest perceptible effect was produced on the circulation of the paper; but when the "Letter to the King" came out (19th Dec. 1769, almost a year from the beginning of the series), it caused an addition of 1750 copies to the ordinary impression. The effect of subsequent letters was variable; but when Junius ceased to write, the *monthly* sale of the paper had risen to 83,950. This was in December 1771. Seven years earlier the monthly sale had been but 47,515. The *Public Advertiser* did not, however, long retain the position into which it had been so rapidly elevated. The *Morning Chronicle* was begun in 1769. William Woodfall ('Memory' Woodfall, as he was called) was its printer, reporter, and editor; and continued to conduct it until 1789. James Perry succeeded him as editor, and so continued, with an interval during which the editorship was in the hands of the late Mr Sergeant Spankie, until his death in 1821. In the days of the "Black Acts" the *Chronicle* was the most uncompromising opponent of the government, and Perry's editorial functions were occasionally discharged in Newgate; in 1819 the daily sale nearly reached 4000. When sold in 1823 to the late Mr Clement, the purchase-money amounted to L.42,000. Mr Clement held it for about eleven years, and then sold it to the late Sir John Easthope, for a much smaller sum than it had cost him. Of its subsequent fortunes, it is enough here to say, that in 1854 its average circulation had sunk to 2791 copies daily. But no loss of popularity can deprive it of the distinction of having been the first newspaper which was adorned by literary criticism of the highest order.

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Letters of Junius in the Public Advertiser.

The Morning Chronicle.

The *Morning Post* dates from 1772. For some years it was in the hands of the notorious 'Parson Bate' (afterwards known as Sir Henry Bate Dudley), and it attained some degree of temporary popularity, though of no very enviable sort. In 1795 the entire copyright, with house and printing materials, was sold for L.600 to Peter and Daniel Stuart, who quickly raised the position of the *Post* by enlisting Mackintosh and Coleridge in its service, and by giving unremitting attention to advertisements and to the copious supply of incidental news and amusing paragraphs. A few years ago there was a long controversy about the share which Coleridge had in elevating the *Post* from obscurity to eminence. That he greatly promoted this result there can be no doubt. His famous "Character of Pitt," published in 1800, was especially successful. It largely increased the sale of the paper, and created a demand for the particular number in which it appeared that lasted for weeks, a thing almost without precedent. Nor were newspaper-owners likely to be at all insensible to the value of talents which bore such a golden stamp. Mr D. Stuart, indeed, was once silly enough to write,—after quoting the anecdote of the city bookseller Sir Richard Phillips having slapped Coleridge on the shoulder at a dinner party, saying, "I wish I had you in a garret without a coat to your back,"—"*In something like this state, I had Coleridge.*" But, when in a better mind, he has borne testimony on this point which is unexceptionable. To write the leading articles of a newspaper, he says, "I would prefer Coleridge to Mackintosh, Burke, or any man I ever heard of. His observations were marked by good sense, ... extensive knowledge, deep thought, and well-grounded foresight. . . . They were the writings of a scholar, a gentleman, and a statesman, without personal sarcasm, or illiberality of any kind." But unhappily, we must add, these noble qualities lacked another. In his best days the poet-philosopher never possessed that capacity for steady, persistent, punctual labour which is the sinew of periodical literature, and for the want

The Morning Post.

Newspaper writings of Coleridge.

[1] Debates of the Irish House of Commons, 3d March 1789.

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of which we have all of us seen names synonymous with genius become symbols of failure. To say, therefore, that it was less to the powers of Coleridge, than to the energetic enterprise and the eminent business qualities of the new proprietors, that the *Morning Post* owed its extraordinary rise, from a daily circulation in 1795 of 350, to one in 1803 of 4500 copies, is consistent alike with the ascertained facts, and with the obvious necessities of the case.

Rapid decline of the Morning Post after 1803.

But it may well excite some degree of wonder to find a journal which had attained such a position sinking within a very few years to a depth of degradation which carried it as far below its competitors as it had formerly risen above them. When Stuart sold his paper in 1803, with its circulation exceeding by one half that of its most popular daily rival, and with a character for honest independence which was still more enviable, he could hardly have anticipated that in 1812 he would read in its columns a poetical address "to the Prince Regent," which, for unblushing falsehood and venal adulation, might challenge the enslaved press of Austria or of Russia. "Glory of the People," "Protector of the Arts," "Mæcenas of the Age," "Conqueror of Hearts,"—such were the epithets thickly strewn in a eulogy which was wound up in this fashion:—

> "Thus gifted with each grace of mind,
> Born to delight and bless mankind;
> Wisdom, with pleasure in her train,
> Great Prince, shall signalize thy reign!"

It was for lashing this vile parasite in terms of manly indignation, and for vigorously enforcing the pregnant truth, "Flattery in any shape is unworthy a man and a gentleman; but political flattery is almost a request to be made slaves," that John Hunt and Leigh Hunt were sentenced to a fine of one thousand pounds; to be, each of them, imprisoned two years in separate gaols; and to give heavy security for good behaviour for five years more.

Repeated augmentation of the newspaper tax.

Whilst the general influence of the newspaper press was becoming both more extensive, and, in the main, incomparably more civilizing, the steady industry of official persons was constantly employed in endeavours to restrain and diminish it. In 1756 an additional halfpenny had been added to the tax. In 1765 and in 1773 various restrictive regulations were imposed (5th Geo. III., c. 46; and 13th Geo. III., c. 65). In 1789 the three halfpence was increased to twopence (29th Geo. III., c. 50); in 1797 to twopence-halfpenny (37th Geo. III., c. 90); in 1804 to threepence-halfpenny (44th Geo. III., c. 98); and, in 1815, was altered to fourpence, less a discount of 20 per cent. Penalties of all kinds were also enhanced, and obstructive regulations were multiplied. Very obviously, these restrictions failed in a great degree of their immediate purpose. Yet their prejudicial effect in eking out the existence of the worst portion of the press, by fettering fair competition, is incalculable. Happily for humanity, there are, and will always be, men to whom obstacles become spurs in the career which conscience has traced for them. Their delight in the chase rises with the difficulty of the country. When once engaged in political conflict, they will, like Defoe, neither give nor take quarter.[1] But the legislation which offers to such men the widest field for their energies, multiplies the basenesses of weaker men, and gives impunity to their crimes.

Before proceeding to notice the later history of the metropolitan newspapers, it may be desirable to glance at the rise and progress of the English provincial press. A glance at it is all that can here be attempted.

Newspapers.

The earliest provincial paper with which we are acquainted is *The Stamford Mercury*, a publication which is still in existence, and of which its proprietors can say, with some reasonable pride, that it has appeared weekly, without interruption, for a hundred and sixty-two years. Next to this came the *Norwich Postman*, first published in 1706, in small quarto, and of meagre contents. The stated price of this paper was a penny, but its proprietor notified to the public that "a halfpenny is not refused." Two other papers were started in Norwich within a few years afterwards,—*The Courant* in 1712; *The Weekly Mercury, or Protestant's Packet* (which still exists) in 1720. Worcester seems to have been the third country town in England to boast of a newspaper; the *Worcester Postman* appearing in 1708, and the *Worcester Journal* having begun its more fortunate career (still continued) in 1709. *The Newcastle Courant* followed in 1711; *The Liverpool Courant* in 1712; the *Salisbury Postman*, and the *Felix Farley's Bristol Journal*, each in 1715; *The Nottingham Post* in 1716; and the *Kentish Post* in 1717. The *Courant* is still published at Newcastle, and the *Kentish Post* (under the altered title of *Kentish Gazette*) at Canterbury. *Farley's Bristol Journal* has merged into the *Bristol Times*. The others have long since ceased to appear.

Growth of the English provincial press.

Early papers of Norwich, Worcester, &c.

The *Leeds Mercury* was established in the year 1718, and, for the purpose of evading the Stamp Act, was made to extend to twelve pages, small quarto (or a sheet and a half; the stamp being then levied only on papers not exceeding a single sheet). Like its contemporaries, it was published weekly, and its price was three-halfpence. In 1729 it was reduced to four pages of larger size, and sold, with a stamp, at twopence. From 1755 to 1766 its publication was suspended, but was resumed in January 1767, under the management of James Bowley, who continued to conduct it for twenty-seven years, and raised it to a circulation of 3000. Its price at this time was fourpence. The increase of the stamp duty in 1797 altered its price to sixpence, and the circulation sank from 3000 to 800. It was purchased in 1801 by the late Edward Baines, who first began the insertion of "leaders." It took him three years to obtain a circulation of 1500; but the *Leeds Mercury* afterwards made rapid progress, and became one of the most important and valuable of the country papers, as it still continues to be.

The Leeds Mercury.

New-Year's-Day 1719 was marked in Manchester by the appearance of the first number of the *Manchester Weekly Journal*, published by Roger Adams. This was followed in 1730 by the *Manchester Gazette* (afterwards called the *Manchester Magazine*), published by Henry Whitworth. *Harrop's Manchester Mercury* was begun on the 3d March 1762, and continued to exist until the close of 1830. Both of the papers last named, although alike characterized by that utter absence of literary talent which usually marked the provincial press of the period, were of violent politics, on opposite sides. The *Magazine* was Whiggish and Hanoverian; the *Mercury*, Tory and Jacobitical. A controversy, which lasted for more than a year, between the former and the *Chester Courant* (a paper that may be regarded as in some sort a continuation of the *Manchester Journal* above-mentioned, the publisher of which had removed to Chester), is not the least curious of the many episodes of the rebellion of 1745–6. It grew out of the following paragraph, which had appeared in the *Mercury* of 23d Sept. 1746:—

Early Manchester papers.

[1] "If I might give a short hint to an impartial writer, it would be to tell him his fate. If he resolves to venture upon the dangerous precipice of telling unbiassed truth, let him proclaim war with mankind *à la mode le pays de Pole*—neither to give nor to take quarter. If he tells the crimes of great men, they fall upon him with the iron hands of the law; if he tells their virtues, when they have any, then the mob attacks him with slander. But if he regards truth, let him expect martyrdom on both sides, and then he may go on fear less; and this is the course I take myself."

Newspapers.

"*Manchester, Sept.* 22.—Last Thursday, about four in the morning, the heads of Thomas Siddal and Thomas Deacon were fixed upon the Exchange. Great numbers have been to view them; and yesterday, betwixt eight and nine in the morning, Dr Deacon, a non-juring priest, and father to one of them, made a full stop near the Exchange, and, looking up at the heads, pulled off his hat, and made a bow to them with great reverence. He afterwards stood some time looking at them."

The incident here recorded was but the spark which fell amidst a large accumulation of combustible matter. Party feeling was at that period in an especial state of excitement in Lancashire; and the paper war which followed afforded matter enough for a volume, under the title of *Manchester Vindicated: Being a complete Collection of all the Papers recently published in Defence of that Town in the Chester Courant.*

The Manchester press during the American war.

Thirty years later, the American revolution rekindled the local bigotry of faction, beneath the mask of patriotism, with even more than its former fierceness. At this period the *Manchester Mercury* published special supplements from time to time, as intelligence came from the seat of war; and whenever the news was unfavourable to the Americans, prefixed headings to the supplements, which served the double purpose of exulting in their defeat and exciting popular hatred against such of the townsmen as were known, or supposed, to regard the colonists in the light of an injured people. Thus, on the 7th January 1777, an extra sheet was published, entitled "No. 1312.—*A New Year's Gift for all true lovers of their King and Country, and a Receipt in full to the most wicked, daring, and unnatural Rebellion that ever disgraced the Annals of History, fomented and abetted by a Junto of Republicans on this side the Atlantic.* Joseph Harrop, printer of the *Manchester Mercury*, with unspeakable pleasure again presents his friends, gratis, with the following *London Gazette Extraordinary*," &c. In the next paper this paragraph was inserted:—

"We are assured by a gentleman just arrived from America, that when Washington found himself reduced to the necessity of quitting his strong entrenchments near King's Bridge, he declared that all was over with the colonies, and dropped some intimation of not wishing to survive the misfortunes of the day. . . . Mr Washington, notwithstanding his amour with Mrs Gibbons, is, we hear, married to a very amiable lady; but it is said that Mrs Washington, being a warm loyalist, has been separated from the General since the commencement of the present troubles, and lives very much respected in the city of New York."

The next supplement begins thus:—"Ye republican fomenters and abettors of rebellion, blush and tremble at your deeds." And another:—"The hour is now approaching when all those vile republican miscreants, as well on this as on the other side the Atlantic (who have fomented . . . a most wicked and horrid rebellion against the best of kings and the best of ministers), must answer for all their mal-practices," &c.

Nor did the utter failure of these predictions teach the conductors or the patrons of the *Mercury* the wisdom of moderation. The same paper, under the same management, fostered the "Church and King" mobs of 1792; incited innkeepers to put up boards bearing the words, "No Jacobins admitted here;" and denounced all opposition to the government of the day as seditious and treasonable. When these frantic counsels had borne their natural fruit of outrage on the property and persons of reformers, the *Mercury* defended the criminals, and those who had failed to put the law in force against them, in these words:—"The fact stands thus: If any man, at such a crisis as this, will publicly make use of expressions inimical to the wellbeing of the government under which he lives, the consequence cannot be arrested by the best-regulated police, because it will be summary." At this time, Manchester possessed no paper of any shade of liberalism. The printing-office of the *Manchester Herald*, which had been started on the 31st March 1792, as the advocate of moderate reform, was partially destroyed by a mob in the month of December following; the local authorities of the town standing by and applauding the act; and the paper itself ceased to appear in March 1793. *The York Courant* dates its first appearance in 1719; *The Northampton Mercury* and *The Salisbury Journal* date from 1720; *The Gloucester Journal* from 1722; *The Reading Mercury* from 1723; *The Chester Courant* (already mentioned) and *The Chelmsford Chronicle* from 1730; *The Kendal Courant* appeared in 1731; *The Derby Mercury* dates from 1732; *The Sherborne Mercury* (now called *The Western Flying Post*) from 1736; *The Hereford Journal* from 1739; *Aris's Birmingham Gazette* from 1741; *The Bath Journal* from 1742; and *The Cambridge Chronicle* from 1748. The total number of *existing* provincial newspapers, the first publication of which is prior to 1750, is eighteen. Twenty-nine others have dates which range between the years 1750 and 1790. Most other country papers date their origin subsequently to the middle of the last century.

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Other English papers prior to 1750.

The Times is usually dated from the 1st of January 1788, but was really commenced on the 18th January 1785, under the title of *The London Daily Universal Register, printed logographically.* This "word-printing" process had been invented by a person named Henry Johnson several years before, and is the subject of two patents, bearing date, respectively, 9th November 1778, and 16th October 1780. The first of these is described as a "method of printing with types or figures so connected as to prevent the possibility of error in all business where figures are used, particularly in taking down the numbers of blanks and prizes in the lottery." The second is described as a "method of casting and moulding types for the purpose of composing by or with entire words, with several words combined, with sentences, and syllables, and figures combined, instead of the usual method of composing and printing with single letters," &c. These patents were Johnson's; but the invention was eagerly taken up by Mr Walter (himself a printer), who was sanguine of its success. His *Daily Register* contained four pages, was printed on a halfpenny stamp, and was at first sold for twopence-halfpenny, afterwards for threepence. In Nos. 510 and 511 Mr Walter made a long address to the public on the advantages of the logographic plan, and of the obstacles it had encountered. "Embarked in a business," he writes, "into which I entered a mere novice, ... want of experience laid me open to many and gross impositions; and I have been severely injured by the inattention, ignorance, and neglect of others. These reasons, though they will not excuse, will account for and palliate the errors . . . . of the logographic press," &c. And he proceeds to state that the impediments thrown in his way, by the typefounders in particular, were such as to oblige him to erect a foundry for himself. In short, it is the old story of all inventors, differenced in this case from many others by the circumstance, that here there were difficulties in the way of ultimate and permanent success which seem to have been really insuperable.

Origin of The Times newspaper.

Johnson's patents for logographic printing.

Another obstacle in Mr Walter's path will be best described in his own words:—

"*The Universal Register* has been a name as injurious to the *logographic newspaper*, as Tristram was to Mr Shandy's son. But old Shandy forgot he might have rectified by confirmation the mistake of the parson at baptism—with the touch of a bishop have, altered Tristram to Trismegestus. *The Universal Register*, from the days of its first appearance to the day of its confirmation, has, like Tristram, suffered from unusual casualties, both laughable and serious, arising from its name, which, on its introduction, was immediately curtailed of its fair proportion by all who called for it,—the word *Universal* being universally omitted, and the word

The Daily Universal Register changed into The Times.

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Register being only retained. 'Boy, bring me the *Register*.' The waiter answers, 'Sir, we have not a library, but you may see it at the New Exchange Coffee-House.' 'Then, I'll see it there,' answers the disappointed politician; and he goes to the New Exchange, and calls for the *Register*, upon which the waiter tells him that he cannot have it, as he is not a subscriber, and [or?] presents him with the *Court and City Register*, the *Old Annual Register*, or the *New Annual Register*. . . . . For these and other reasons, the parents of the *Universal Register* have added to its original name that of the *Times*, which, being a monosyllable, bids defiance to corrupters and mutilators of the language." (*The Times, or Daily Universal Register*, printed logographically . . . . for J. Walter, at the Logographic Press, Printing-House Square, &c. No. 1, 1st January, 1788.)

Within two years Mr Walter had his share in the Georgian persecutions of the press, by successive sentences to three fines and to three several imprisonments in Newgate, chiefly for having stated that the Prince of Wales and the dukes of York and Clarence had so misconducted themselves "as to incur the just disapprobation of his Majesty." In 1803 he transferred the management of the journal to his son, the late Mr Walter (together with the joint proprietorship), by whom, as is well known, it was carried on with remarkable energy and consummate tact. To Lord Sidmouth's government he gave a general but independent support. That of Mr Pitt, which succeeded, he opposed, especially on the questions of the Catamaran expedition and the malversation of Lord Melville. This opposition was characteristically resented by depriving the elder Mr Walter of the printing of the Customs department, which he had performed for eighteen years; by the withdrawal of government advertisements from the *Times*; and by the systematic detention at the outports of the foreign intelligence addressed to its editor. Mr Walter, however, was strong and resolute enough to brave the government, and to beat it. He organized a better system of news transmission than had ever before existed. He introduced steam-printing, and repeatedly improved its mechanism; and although machines which now print 12,000 sheets in the hour may seem to thrust into insignificance a press of which it was at first announced as a notable triumph that the new machine performed its task "with such a velocity and simultaneousness of movement, that no less than 1100 sheets are impressed in one hour;" yet Mr Walter's assertion was none the less true, that the *Times* of 29th November 1814 "presented to the public the practical result of the greatest improvement connected with printing since the discovery of the art itself."

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The Times' steam printing-press.

The effort to secure for the *Times* the best attainable literary talent in all departments kept at least an equal pace with those which were directed towards the improvement of its mechanical resources. And thus it has come to pass that a circulation which did not, even in 1815, exceed on the average 5000 copies, became, in 1834, 10,000; in 1844, 23,000; in 1851, 40,000; and in 1854, 51,648. In the year last named, the *Morning Advertiser*, the most popular of its daily contemporaries, attained an average circulation of but 7668; whilst that of the *Daily News* was but 4160; that of the *Morning Herald*, 3712; of the *Morning Chronicle*, 2800; and of the *Morning Post*, 2667. But this extraordinary fact will be best appreciated if the average daily circulation of the *Times*, for a few years past, be compared with that of *all* its daily contemporaries of the London press collectively:—

Growth of the circulation of the Times.

	Year 1846.	1847.	1848. European Revolution.	1849.	1850.	1851.	1852.	1853.	1854. Russian War.
The Times	28,594	29,409	35,225	36,102	38,019	40,081	42,384	44,578	51,648
Aggregate of the other Daily Morning Papers	38,999	33,945	34,558	25,347	24,116	30,266	29,580	28,768	26,268
Total average circulation of Daily Morning Papers	67,593	63,354	69,783	61,449	62,135	70,347	71,964	73,346	77,916

The Times and the continental banking forgeries of 1840.

Of the many curious incidents which occur in the public history of the *Times*, one only can here be mentioned. That one is too honourable to journalism, and has been too useful in its results to the community, to be passed over. In 1840, the then Paris correspondent of this paper (Mr O'Reilly) obtained information respecting a gigantic scheme of forgery which had been planned in France, together with particulars of the examination at Antwerp of a minor agent in the conspiracy, who had been there, almost by chance, arrested. All that he could collect on the subject, including the names of the chief conspirators, was published by the *Times* on the 26th of May in that year, under the heading, "Extraordinary and Extensive Forgery and Swindling Conspiracy on the Continent (Private Correspondence)." The project contemplated the almost simultaneous presentation, at the chief banking-houses throughout the Continent, of forged letters of credit, purporting to be those of Glyn and Company, to a very large amount; and its failure appears to have been in a great degree owing to the exertions made, and the heavy responsibility assumed, by the *Times*. One of the persons implicated brought an action for libel against the printer, which was tried at Croydon in August 1841, with a verdict for the plaintiff, *one farthing damages*. A subscription towards defraying the heavy expenses (amounting to more than L.5000) which the *Times* had incurred, was speedily opened, but the proprietors declined to profit by it; and ultimately it was determined, that of the sum (L.2625) which had been raised, an amount not exceeding one hundred and fifty guineas should be expended on two commemorative tablets,—the one to be placed in the *Times* office, and the other in the Royal Exchange; the remainder of the money being funded, and the dividends applied to the support of two "*Times*' scholarships," in connection with Christ's Hospital and the City of London School, for the benefit of pupils proceeding thence to the universities of Oxford or Cambridge. This scheme was carried into effect in 1842.

The Times scholarships.

Repeated failures of new attempts to establish London daily papers.

For upwards of sixty years from the establishment of the *Times*, only one of the many attempts that were made to found a new daily paper in London was successful. The most conspicuous failures were those of the *New Times* (started by Dr Stoddart, better known as "Dr Slop"); of the *Representative* (in which the late Mr John Murray risked and lost a very large sum); and of the *Constitutional* (originated by a joint-stock subscription, under the title of "The Metropolitan Newspaper Company"). All these failures were complete, notwithstanding that neither talent, industry, nor money seems to have been wanting to give the new papers a fair start. Of the latter, indeed, about L.50,000 was lost in these three unsuccessful attempts. The stamp may have had its influence in promoting these miscarriages, but the main cause of them lay in the unremitting energy, the wide forecast, and the practical wisdom with which their most formidable rival provided for and anticipated the wants of the public. The lesson is an instructive one, well deserving to be thoroughly studied by all whom it may concern.

Establishment of the Morning Advertiser, and of the Daily News.

In the exceptional case, that of the *Morning Advertiser*, the new paper attained commercial success by reason of its special character, as being at once the representative of the interests and of the charities of the Licensed Victuallers. Every publican who subscribed to it had his share in the profits. The subsequent success of the *Daily News* (the first number of which appeared in 1846), after a long and

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severe struggle, has been mainly due to the ready skill with which it corrected its early blunders, and turned them to future account. Its literary staff was strong, and its enterprise, especially in relation to the early obtainment of foreign news, remarkable. For a time, too, it offered to the public a tolerably complete newspaper for twopence-halfpenny; but under the then existing circumstances this could not continue. In January 1847 the price was raised to threepence, and at this price it reached a daily sale at one time of 23,000 copies, and managed for a while to hold its own against a formidable combination of rivals. In February 1849 it resumed its original size, and was sold at the usual price of fivepence. Its average sale in 1854 was (as we have seen) only 4160. But it has always held a highly respectable place in the ranks of metropolitan journalism.

London evening newspapers.

London possessed no *daily* evening paper until 1788, nor did any evening paper attain an important position until the period of the war with Napoleon, when the *Courier* became the newspaper of the day. During the last three years of that war its average daily circulation reached 8000 copies. After the peace its popularity declined, and eventually a total change in its politics completed its ruin. The *Globe* and the *Sun*, as independent papers, and the *Express* and the *Evening Mail*, as offshoots respectively of the *Daily News* and of the *Times*, are now the principal journals of their class.

London weekly newspapers.

The London weekly press has always worn a motley garb. In its ranks are to be found some of the most worthless newspapers and some of the best. Weekly publication facilitates the individuality of a journal, both as respects its editorship, and as respects the class of readers to which it more especially addresses itself. From the days of Daniel Defoe to those of Albany Fonblanque and Robert Rintoul, there have always been newspapers bearing the unmistakeable impress of an individual mind. And this characteristic quality, whilst it has strengthened and deepened the influence of good journals, has also, of necessity, increased the temporary power of bad journals. When to great force of character in the writer and its natural result, an almost personal intimacy between writer and reader, governments have been unwise enough to add the strength which inevitably grows out of persecution, the combination might well prove a formidable one. Cobbett's *Weekly Register* affords perhaps as striking an illustration of journalism, in its greatness and in its meanness, as could be culled from its entire annals since a newspaper was first issued.

Cobbett's Weekly Register.

When Cobbett commenced his *Political Register* in the year 1802, its plan was very different from that which he ultimately adopted. The author was at first chiefly anxious to make his work a good repertory of state papers; but his point of view soon changed. What had been intended as a storehouse of materials for the future historian became a record of the varying moods of mind under which a man of remarkable powers regarded the passing events of the day. The extraordinary success of the paper was mainly owing to the vividness with which these impressions were recorded; to the clear and vigorous English, racy of the soil, in which they were clothed; and, above all, to the evidence it carried on its face that the writer, whatever his other faults, was not to be bribed, and that he meant what he said—at least whilst he was saying it. Egotism beyond all precedent, hatreds the most vindictive, and inconsistencies so numerous, that after a time opponents ceased to take note of them, were qualities in this paper so apparent that he who ran might read; and three-fourths perhaps of the topics which came under notice were discussed with a lack of information and a shallowness of thought that were quite as striking as was the blaze of light in which the writer placed the remaining fourth. To William Cobbett no question was so difficult, and no name so sacred, as to call for modest or reverent silence. Of reverence, in truth, he had none. Cobbett's French Grammar seemed to him a greater work than the *Paradise Lost;* and the chief impression he derived from the writings of Addison was, that they afforded copious examples of faulty syntax. To him all subjects were almost equally welcome, were handled with like confidence, and afforded similar opportunities for bitter personality and fierce invective. Yet the *Weekly Political Register* maintained a popularity that was almost unexampled. Cobbett carried it on during thirty-three years, and amidst all varieties of fortune. Whether he was at home or on his travels, a prisoner in Newgate or an exile in America, the work went steadily on, until it had filled 88 volumes, and then his labour ceased but with his life. He owed to it an influence that was co-extensive with the empire, and that made his name a household word at the hearths of tens of thousands who had never set eyes upon him. But if it be asked, what was the real outcome of all this rare energy and untiring industry, in the way of enlightening and elevating that numerous public whose ear it had gained, a truthful answer will be a sad one. Here and there it set a-thinking men who had capacity enough to seek further and better instruction elsewhere; but to a large proportion of its readers, the *Register* became a sort of political gospel. Nor is it uncharitable to say, that some of the worst excesses of "Chartism"—its bigotry and rancour, its short-sighted obstruction of social improvements, and its obstinate pursuit of courses leading to riot and outrage—are partly ascribable to the one-sided teachings and the frantic violence of the *Weekly Register*. Misgovernment, indeed, was the seed-plot; but these were potent fertilizers. Whatever else may have been wanting to insure a large crop was amply afforded by the results of the pertinacious maintenance of the newspaper stamp, and of those other impediments which then so thickly studded the path of every temperate and truth-loving writer who sought to address himself to the masses of his countrymen, without either flattering their vanity or exciting their passions.

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Effect of the Weekly Register teaching on subsequent history of Chartism.

The manifest incongruity between the maintenance of "taxes on knowledge" and the pretensions of a reforming government, gave a strong impulse to the violation of the law. Between the years 1831 and 1835 many scores of unstamped newspapers made their appearance. *Poor Man's Guardians, Twopenny Dispatches, Destructives, People's Conservatives, London Democrats,* and a host of other penny and halfpenny papers swarmed from presses that seemed to rival, in their mysterious itinerancy and sudden vanishings, the famous Marprelate press of the sixteenth century. The political tone of most of them was fiercely revolutionary. Some of them taught Marat's doctrine that the shortest and surest path to political amelioration lies through a sea of blood. Those of the latter class were characterized by Lord Brougham (when under examination in a committee of the House of Commons on the libel law), as competing one with the other in the ferocity of their writings. "Where one," he says, "charged public characters with all offences, another recommended their extirpation; where one maintained the lawfulness of rebellion, another maintained the propriety of assassination." Prosecution after prosecution failed to suppress the obnoxious publications. The total number of such prosecutions exceeded 700, and nearly 500 persons suffered imprisonment in the course of them. But the law continued to be systematically broken.

The unstamped press of the Reform Bill period.

To Sir Edward Bulwer Lytton is due the credit of having grappled with this question in the House of Commons, in a manner which secured the speedy reduction of the tax from fourpence to a penny, and paved the way towards its subsequent though long-delayed abolition. This reduction took effect on the 15th September 1836. At that date the number of newspapers stamped in Great Britain and Ireland was about 36,000,000 in the year, and the gross amount of duty upwards of L.553,000. Of this sum English news-

Reduction of the stamp-duty in Sept. 1836.

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papers paid L.473,910; Scottish newspapers, L.47,999; and Irish newspapers, L.31,287. In the year ending 5th January 1838, the first financial year during the whole of which the reduced duty was in operation, the number of stamps issued throughout the United Kingdom was raised to 53,897,926, and the gross amount of the duty was reduced to L.223,425, 10s. 11d. Of this sum English newspapers paid L.182,998, 3s. 2d.; Scottish newspapers, L.18,671, 13s. 3d.; and Irish newspapers, L.21,755, 14s. 6d. In the year ending 5th January 1849, the number of stamps had risen to 86,465,684, and the gross amount of duty was L.360,273, 12s. Finally, in the year ending 5th January 1855, the number of stamps issued to newspapers, exclusive of price-currents, &c., at the rate of one penny,—to which rate the parliamentary return before us is limited,—was 107,052,053, and the gross amount of duty thereon, L.446,050. The details are as follows:—

Number of stamps, and amount of duty, subsequently to the reduction in 1836.

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United Kingdom.	Number of Newspapers stamped.	Aggregate No. of 1d. Stamps issued to Newspapers.	Gross Amount of Duty thereon.
			L. s. d.
England	412	87,930,085	366,375 7 1
Wales	21	1,107,434	4,614 6 2
Scotland	102	9,112,245	37,967 13 9
Ireland	108	8,902,289	37,092 17 5
Total	643	107,052,053	446,050 4 5

At the date of this return (January 1855), the relative consumption of ordinary stamps, and the average circulation of the principal newspapers, stood respectively thus:—

Relative circulation of the principal newspapers in 1854.

Name of Newspaper.	Date of Establishment.	Periods of Publication in 1855.	Politics.	No. of Penny Stamps in 1854.	Average Circulation in 1854.
1. Times—[See also Evening Mail]	1785	Daily	Liberal	15,975,739	51,040
2. News of the World	1843	Weekly	Do.	5,673,525	109,106
3. Illustrated London News	1842	Do.	Do.	5,627,866	108,228
4. Lloyd's Weekly Newspaper	1842	Do.	Democratic	5,572,897	107,171
5. Weekly Times	1847	Do	Liberal	3,902,169	75,041
6. Reynolds' Weekly Newspaper	1850	Weekly	Democratic	2,496,256	48,005
7. Morning Advertiser	1794	Daily	Liberal	2,392,780	7,644
8. Dispatch	1801	Weekly	Do.	1,982,933	38,133
9. Daily News	1846	Daily	Do.	1,485,099	4,744
10. Bell's Life in London	1820	Weekly	Do.	1,161,000	22,326
11. Morning Herald	1781	Daily	Conservative	1,158,000	3,699
12. Manchester Guardian	1821	Twice a week	Liberal	1,066,575	10,255
13. Dublin Telegraph	1852	Weekly	Do.	959,000	18,442
14. Liverpool Mercury	1811	Four times a week	Do.	912,000	4,384
15. Morning Chronicle	1770	Daily	Conservative	873,500	2,790
16. Globe	1803	Do.	Liberal	850,000	2,715
17. Express	1846	Do.	Do.	841,341	2,688
18. Morning Post	1772	Do.	Conservative	832,500	2,659
19. Sun	1792	Do.	Liberal	825,000	2,635
20. North British Advertiser (Edinburgh)	1826	Weekly	Neutral	802,000	15,423
21. Evening Mail	1789	Three times a week	Liberal	800,000	5,128
22. Saunders' News-Letter (Dublin)	1746	Daily	Neutral	756,000	2,415
23. Dublin Daily Express	1851	Do.	Conservative	748,500	2,391
24. Leeds Mercury	1718	Twice a week	Liberal	735,500	7,072
25. Glasgow Saturday Post	1830	Weekly	Do.	727,000	13,980
26. Stamford Mercury	1695	Do.	Do.	689,000	13,250
27. Birmingham Journal	1825	Twice a week	Do.	650,750	6,257
28. Manchester Examiner and Times	1846	Do.	Do.	636,000	6,115
29. Shipping and Mercantile Gazette	1836	Daily	Neutral	628,000	2,019
30. Bell's Weekly Messenger	1796	Weekly	Conservative	625,500	12,028
31. Dublin General Advertiser	1837	Do.	Neutral	598,000	11,500
32. North British Mail (Glasgow)	1847	Daily	Liberal	565,000	1,805
33. Glasgow Herald	1803	Three times a week	Conservative	541,500	3,471
34. Dublin Freeman's Journal	1763	Daily	Liberal	480,000	1,533
35. Staffordshire Advertiser	1795	Weekly	Neutral	425,633	8,185
36. Leeds Times	1833	Do.	Liberal	421,500	8,105
37. London Gazette	1655	Twice a week	Neutral	420,000	4,035
38. Observer	1792	Weekly	Liberal	419,000	8,057
39. Standard	1827	Daily	Conservative	417,000	1,332
40. St James's Chronicle	1761	Three times a week	Do.	415,000	7,980
41. Scotsman (Edinburgh)	1817	Twice a week	Liberal	359,000	3,451
42. Witness ,,	1840	Do.	Do.	297,000	2,855
43. Examiner	1808	Weekly	Do.	248,560	4,780
44. Spectator	1828	Do.	Do.	142,000	2,730

Final repeal of the compulsory stamp-duty in 1855.

The penny stamp, so far as it was compulsory, was at length entirely repealed by an act of Parliament, which received the royal assent on the 15th of June 1855. Mr Milner Gibson had, in the previous session, carried a resolution of the House of Commons affirming "that it is the opinion of this House that the laws in reference to the periodical press and newspaper stamp are ill defined and unequally enforced; and it appears to this House that the subject demands the early consideration of Parliament." This resolution necessarily brought the subject under the attention of the government, and especially of Mr Gladstone, then chancellor of the exchequer. That minister did not retain office long enough to introduce his measure into Parliament; but his successor took up the bill he had prepared, and with some modification carried it into a law. It continued to be practicable to stamp newspapers for transmission by post; and in respect of all newspapers any part of the impression of which should be so stamped, the existing regulations as to the declaration, registration, and recognisances of newspaper proprietors remained in force. In the course of the debates the chancellor of the exchequer acknowledged that the question had become "not simply a question whether we

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shall retain or shall not retain a revenue of L.200,000,"—(this was said on the assumption that about one-half of the net revenue arising from the stamp would continue to be received),—"but it is whether we shall enter upon a crusade against a large portion of the existing newspaper press, for the sake of enforcing a law which can only be enforced by means of the verdicts of juries, which are somewhat doubtful in their result." Mr Drummond amused the House after his fashion with a summary of the history of the newspaper press, as it shaped itself to his fancy, in the course of which he said that the writers in the *Times* "reminded him a good deal of what they called on board ship a 'handy-billy,'—a tackle that came in upon all occasions whenever it was wanted;" and also, "of a bit of bog he had near a farm of his. He once thought of draining it, and asked the opinion of the farmer, who replied,—'No, no! don't drain it; in wet weather there's something for the cow; and if there's nothing for the cow, there's something for the pig; and if there's nothing for the pig, there's something for the goose.' So it was with the *Times*; if there was nothing in it for one man, there was sure to be something for another." In the division at the second reading, taken on an amendment professedly for delay, but substantially intended to defeat the measure, the ayes were 215, the noes 161, the majority 54. In the House of Lords no division took place; but Lord Monteagle recorded a protest against the bill, grounded partly on fiscal objections, and partly on the assertion that the proposed remission, "so far from being sought for as a relief to the class of newspaper proprietors whose interests are primarily involved in the question, is, on the contrary, earnestly deprecated by them as being likely to lead, through an unjust and unchecked piracy, to the depreciation of their capital and the sacrifice of their commercial interests." It was pertinently rejoined by Lord Canning:—"This in no way affects the justice of the question. It will be remembered that not many shipowners petitioned for the alteration of the navigation laws, nor many farmers for the repeal of the corn laws."

Lord Monteagle's protest against the repeal.

Thus was struck out from the statute-book a law which had been thrust upon it at a time of unusual excitement, in opposition to the counsels of the best statesmen of the day, but which, nevertheless, continued in force for a hundred and forty-three years. During that long term it uniformly showed itself to be potent for mischief, and powerless for good. Any period of unusual stringency in the execution of it was invariably marked by rampant misgovernment, crowded gaols, and wide-spread discontent. At length the contrast between professions of anxiety for the promotion of popular education, and an obstinate perseverance in impeding the progress of one of the most efficient of popular educators, became too glaring to be longer endured. It deserves to be remembered, that at this final stage, although there was a formidable array of maintainers of the stamp, not one of the number was bold enough to avow any sympathy with the reasons for supporting it which had so often been candidly asserted by writers like L'Estrange, and by statesmen like North and Pitt. In these days no politician has either fear or dislike of an unshackled press. His only alarm is, lest in losing its fetters, it should lose its character.

The interval since the repeal is as yet too brief to afford materials for any satisfactory estimate even of the immediate results. We close this section of the subject, therefore, with a brief statistical statement of the present position of the British newspaper press; first, however, prefixing a tabular summary of the operation of the stamp duty at various periods of its existence.

Year.	Population at the Decennial Periods of the Census.	Chief Political Events or Topics of the Year.	Number of Stamps Issued.		Rate of Duty (Net).
1753	[England, 6,186,366	.....	England.	7,411,757	1½d.
1760	Do. 6,479,730	.....		9,464,790	...
1790	Do. .....8,540,738]	French Revolution.....		14,035,639	2d.
1801	Great Brit., 10,942,646	War with Napoleon.....	Great Britain.	16,085,085	...
1806	.....	Do.		20,532,793	3d.
1811	Do. 12,596,803	Do.		24,424,713	...
1814	.....	Defeat of Napoleon.....		26,308,003	...
1815	.....	Waterloo campaign		24,385,508	3½d.
1816	.....	Congress of Vienna.....		22,050,354	...
1817	.....	Discontent in England.....		24,277,464	...
1818	.....	Peterloo massacre		24,718,541	...
1819	.....			23,048,449	...
1820	Unit. King., 21,272,187	Trial of Queen Caroline.....		29,387,843	...
1825	.....	Catholic Association		30,451,176	...
1826	.....	Commercial distress.....		30,453,566	...
1828	.....	Catholic emancipation.....		32,585,481	...
1829	.....			32,989,884	...
1830	.....	French Revolution of July		34,540,496	...
1831	Do. 24,392,485	Reform Bill agitation		37,713,068	...
1832	.....			37,210,691	...
1834	.....	.....		34,748,922	...
1835	.....	Peel-Wellington administration		35,823,859	...
1836	.....	Stamp duty reduced Sept. 15, to 1d.		39,423,200	Part of the year, 3½d. From Sept. 15, 1d.
1837	.....	First year of penny stamp.....	Great Britain and Ireland.	53,897,926	...
1838	.....	.....		53,680,880	...
1839	.....	Chartist agitation.....		58,981,078	...
1841	Do. 27,036,450	.....		60,759,392	...
1842	.....	Commencement of the systematic agitation of Corn Law repeal..		62,651,342	...
1843	.....			65,074,219	...
1844	.....	Corn Law agitation		69,054,067	...
1845	.....			78,586,650	...
1846	.....	Repeal of the Corn Laws.....		83,074,638	...
1847	.....	Famine in Ireland.....		82,380,875	...
1848	.....	French Revolution of February European insurrections		86,465,684	...
1849	.....	.....		84,069,472	...
1851	Do. 27,724,849	.....		91,600,000	...
1852	.....	.....		Amount of duty, L.421,811 1 7	
1854	.....	War with Russia.....		122,178,501[1]	...
1856	.....	.....		39,184,474	Optional stamp.

1 Inclusive of prices current, trade lists, &c., and of halfpenny stamps for supplements.

Newspapers.

The number of newspapers commenced from the early part of 1855, when the repeal of the stamp duty had become a certainty, although not actually accomplished, and which continued to be in existence at the beginning of 1857, amounts to 107. Eighty of these were started in 1855, and twenty-seven in 1856; twenty-six are metropolitan, and eighty-one provincial. Of the latter, the majority belong to towns which possessed no newspaper whatever under the compulsory stamp act, and the price of nearly one-third of them is but a penny. In some cases, however, a portion of these new cheap papers is printed in London, usually with pictorial illustrations, and to this is added a local supplement containing the news of the district.

Number of newspapers current in 1857.

The total number of the newspapers published throughout the United Kingdom at the beginning of 1857 was 711; and they may be classified as follows:—

Newspapers of	England.		Wales.	Scotland.	Ireland.	Isle of Man and Chan. Islands.	Total.
	Metropolitan.	Provincial					
Liberal politics.....	40	134	7	66	38	4	289
Democratic „	3	...	...	...	...	...	3
Conservative „	20	90	5	16	38	4	173
Neutral „	38	131	7	30	35	5	246
Total number.....	101	355	19	112	111	13	711

If these existing newspapers be classified according to their respective dates of first publication, the enumeration will run thus:—

Date of Publication.	England.		Wales.	Scotland.	Ireland.	Isle of Man.	Total.
	Metro.	Prov.					
First pub. prior to year 1700	1	1	...	2	...	...	4
betw. 1701 & 1750	...	17	...	2	3	...	22
„ „ 1751–60	1	2	...	...	1	...	4
„ „ 1761–70	2	5	...	1	3	...	11
„ „ 1771–80	1	6	...	...	4	...	11
„ „ 1781-90	3	9	...	...	...	1	13
„ „ 1791–1800	6	9	...	3	...	...	18
„ „ 1801–10	3	14	3	6	6	...	32
„ „ 1811–20	2	17	...	6	4	4	33
„ „ 1821–30	7	20	1	5	13	3	49
„ „ 1831–40	13	50	2	16	19	1	101
„ „ 1841–50	27	47	4	29	27	...	134
„ „ 1851–54	10	76	3	14	12	1	116
„ in 1855	13	67	4	21	9	2	116
„ „ 1856	12	15	2	7	3	1	40
First publication uncertain.	...	...	...	...	7	...	7
Total number.	101	355	19	112	111	13	711

Postal transmission of newspapers in 1855 and 1856.

The decrease in the number of newspapers which passed through the post-office in the year 1855 (during exactly one-half of which the compulsory stamp had been abolished), amounted to about one-fourth of the aggregate number which had been posted in the preceding year. During the six months of the optional stamp the money received for impressed stamps was about L.93,000, and that for postage stamps affixed on newspapers about L.25,000. In the year 1856 the number of newspapers which passed through the post-office was nearly 71,000,000, and of these about three-fourths bore the impressed stamp, and one-fourth was franked by the ordinary postage stamps. The total gross revenue was therefore about L.295,833. Prior to the abolition of the compulsory stamp the average weight of the newspapers passing through the post-office was three ounces and a half. It is now about two ounces and three-quarters. The reduction is due to the increase of the small and cheap papers. It is understood that *The Times* stamps about forty per cent. of its entire impression, the daily average of which exceeds 60,000. It need hardly be added that the alteration of the law, and the consequent multiplication of the cheaper newspppers, have diminished neither the circulation nor the well-earned influence of the leading journal.

Newspapers.

Formalities to be observed in the establishment of a new journal.

The establishment of a newspaper still requires compliance with most of the regulations of the 6 and 7 Will. IV., c. 76. Notice must be given at the Inland Revenue Office in London, or at the district stamp-office in the country, of the contemplated publication, with particulars of (1.) title; (2.) precise locality of printing and publishing offices; (3.) names in full of printers and publishers; (4.) number of shares held by each proprietor, if there be more than one, with their names, occupations, and places of abode. This declaration must be made by the proprietor or by the proprietors jointly, if not exceeding two; if otherwise, then by the two largest shareholders. The security of two sureties (L.400 in London, L.300 in the country) is still required as a provision against the infraction of the libel law. Each paper must bear the printer's and publisher's name as heretofore, and a copy must be deposited at the stamp-office (for which payment is made). The impressed stamp carries the paper bearing it through the post-office for any number of re-transmissions, if within fifteen days of publication. Afterwards it is subject to the ordinary regulations of the book-post. To entitle newspapers to transmission to the colonies or to foreign countries, they must, in addition to the payment of postage, according to the ordinary rates, be specially registered, and an annual fee of five shillings must be paid, which is due on the 15th June in each year. (Miscellaneous newspapers in the Burney and other collections of the British Museum; Nichols, *Literary Anecdotes of the Eighteenth Century*, iv. 33–97; *Returns relating to Newspaper Stamps*, 1836–1854; *Report of the Select Committee on Newspaper Stamps*, 1850, passim; Watts, *Letter to Antonio Panizzi, Esq.*, on the reputed *English Mercury* of 1588; Hansard's *Parliamentary Debates*, Sessions 1835, 1836, 1853, 1854, and 1855; Hunt, *The Fourth Estate*, passim; Coleridge, *Biographia Literaria*, Supp. 392–395; *Life of Edward Baines*, 346, seq.; *Edinburgh Review*, Oct. 1855, art. "The Newspaper Press;" Mitchell, *The Newspaper Press Directory, for* 1857, passim; *Second and Third Reports of the Postmaster-General*, 1856, 19; 1857, 10, seq.; Scott, *Memoirs of Swift*, 130, seq.; *First Report of the Commissioners on the Inland Revenue*, 1857, 28; cxxiv.)

II.—THE NEWSPAPERS OF THE UNITED STATES OF AMERICA.

Boston was the first city of America that possessed a local newspaper; but the earliest attempt in that direction, made in September 1690, was suppressed by the authorities. So far as is now known, the only copy of this pioneer of the vast newspaper press of the United States which escaped destruction, is the copy that may still be seen in the State Paper Office in London. It is a small quarto sheet, one of the four pages of which is blank; the other three contain a record of passing occurrences, not unlike the contemporary news of the English press; and with little on the face of it to justify, in any sense, the assertion that "it contained reflections of a very high nature." Although it purports to be "printed by Richard Pierce for Benjamin Harris," it is probable that the latter was both printer and editor, as he had already been of a London paper, and was again at a subsequent period. Nearly fourteen years afterwards (April 24, 1704), the first number of the *Boston News-Letter* was "printed by B. Green, and sold by Nicholas Boone;" but its proprietor and editor—so far as it can be said to have had an editor, for extracts from the London papers were its staple contents—was John Campbell, postmaster of the town. In 1719 he enlarged his paper, in order, as he told his readers, "to make the news newer and more acceptable; . . . . whereby that which seem'd old in the former half-sheets becomes new now by

Campbell Boston News-Letter.

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the sheet. . . . . This time twelvemonth we were thirteen months behind with the foreign news beyond Great Britain [or, in other words, the attention of the Bostonian politicians was engrossed on the siege of Belgrade, when their contemporaries in the mother country were intent on the destruction of the Spanish fleet on the coast of Sicily]; and now less than five months; so that . . . . we have retrieved about eight months since January last;" and he encourages his subscribers with the assurance that if they will continue steady "until January next, life permitted, they will be accommodated with all the news of Europe . . . . that are needful to be known in these parts." But Campbell's new plans were soon disturbed by the loss of his office, and the commencement of a new journal by his successor in the postmastership, William Brooker, entitled the *Boston Gazette*, "published by authority" (No. 1, 21st December 1719). The old journalist had a bitter controversy with his rival, but at the end of the year 1722, relinquished his concern in the paper to Benjamin Green, by whom it was carried on with higher aims and greater success. The following passage from an address to his readers (7th March 1723), may deserve quotation:—

Green's editorship of the Boston News-Letter.

"The design of this paper is not merely to amuse the reader, much less to gratify any ill-tempers by reproach or ridicule, to promote contention, or espouse any party among us. The publisher, on the contrary, laments our unhappy and dangerous divisions, and he would always approve himself as a peaceable friend and servant to all. . . . . He longs for the blissful times when wars shall cease to the end of the earth. . . . . The publisher would therefore strive to oblige all his readers by publishing those transactions that have no relation to any of our quarrels. For this end he proposes to extend his paper to the history of nature among us, as well as of political and foreign affairs. . . . . That so this paper may in some degree serve for the *Philosophical Transactions of New England*, as well as for a political history; and the things worthy of recording in this, as well as in other parts of the world, may not proceed to sink into eternal oblivion, as they have done in all the past ages of the aboriginal and ancient inhabitants."

Green conducted the paper until his death, at the close of 1733, and was succeeded by his son-in-law, John Draper, who published it until December 1762. By Richard Draper, who followed his father, the title was altered to *Massachusetts Gazette and Boston News-Letter;* and the maintenance of the British rule against the rising spirit of independence uniformly characterized his editorship and that of his widow (to whom, at a subsequent period, a pension was granted by the British government). It was the only paper printed in Boston during the siege, and ceased to appear when the British troops were compelled to evacuate the city.

The Boston Gazette.

The *Boston Gazette* began, as we have seen, in 1719. James Franklin, elder brother of the statesman, was its first printer. It lasted until the end of 1754; its editorship usually changing with the change of the postmasters.

Franklin's New England Courant.

On the 17th August 1721, James Franklin started the *New England Courant*, now memorable for its connection with his illustrious brother. It was soon embroiled in a religious controversy, occasioned by the opposition of the clergy to the practice of inoculation. Many of Franklin's early writings are to be found in its columns; and in February 1722 he assumed its management, James Franklin having been forbidden by the General Court of Massachusetts "to print or publish the *New England Courant*, or any other pamphlet or paper of the like nature, except it be first supervised by the secretary of this province." "The main design of this paper," said the new editor, "will be to entertain the town with the most comical and diverting incidents of human life, which, in so large a place as Boston, will not fail of a universal exemplification. Nor shall we be wanting to fill up these papers with a grateful interspersion of more serious morals, which may be drawn from the most ludicrous and odd parts of life." The publication of the *Courant* ceased in 1727; and two years later Franklin established the *Pennsylvania Gazette*, which he continued weekly until 1765. But for his subsequent fame, both of these papers would perhaps have been utterly forgotten, although their pages might afford useful contributions towards a knowledge of the manners and condition of New England in that day.

Newspapers.

To the *Boston Gazette* and the *Courant* succeeded the *New England Weekly Journal* (20th March 1727; incorporated with the *Boston Gazette* in 1741); and the *Weekly Rehearsal* (27th September 1731), which became the *Boston Evening Post* (August 1735), and under that title was for a time the most popular of the Boston newspapers. It aimed at neutrality in politics, and therefore did not survive the exciting events of the spring of 1775. Several minor papers followed, which may be passed over without notice. A new *Boston Gazette*, which began in April 1755, has, however, claims to be particularized. For a long time it was the main organ of the popular party, and expounded their policy with great ability, and in a dignified temper. Otis, John Adams, Samuel Adams, and Warren were amongst its writers. In January 1775 John Adams began the famous "Letters of Novanglus," the origin of which he has himself (in his Diary) described in these words:—"About this time Draper's paper in Boston swarmed with writers, and among an immense quantity of meaner productions appeared a writer (Daniel Leonard) under the signature of 'Massachusettensis.' . . . These papers were well written, abounded with wit, discovered good information, and were conducted with a subtlety of art and address wonderfully calculated to keep up the spirits of their party and to depress our's; to spread intimidation, and to make proselytes among those whose principles and judgment give way to their fears. . . . . Week after week passed away, and these papers made a very visible impression on many minds. No answer appeared. . . . . I began at length to think seriously of the consequences, and to write under the signature of 'Novanglus;' and continued every week in the *Boston Gazette*, until the 19th of April 1775. The last number was prevented from impression by the commencement of hostilities, and Mr Gill gave it to Judge William Cushing, who now has it in manuscript. An abridgment of the printed numbers was made by some one in England, unknown to me, and published in Almon's *Remembrancer* for 1775, and afterwards reprinted, under the title of *History of the Dispute with America.* In New England they had the effect of an antidote to the poison of 'Massachusettensis.'" This last-named writer spoke more truly than he knew, when he said in reply,—"The changes have been rung so often upon oppression, tyranny and slavery, that whether sleeping or waking, *they are continually vibrating in our ears.*"

Ede's Boston Gazette.

Letters of Novanglus.

The *Massachusetts Spy*, under the indefatigable editorship of the American historian of printing, Isaiah Thomas, did yeoman's service in this struggle, although of a different kind from that of the *Boston Gazette*. The latter spoke chiefly to the thinkers and natural leaders of the people. The *Spy* was a light and active skirmisher who engaged his antagonists wherever he met them, and frequently carried the war into the enemy's country. The *Massachusetts Spy* began its career in July 1770, and had for a considerable time less than 200 subscribers. To its title were added the words "A weekly political and commercial paper, open to all parties, but influenced by none." But the progress of misgovernment, and the energies of its editor's own character, soon led to a change in this respect, which was sufficiently indicated by the introduction of a motto from *Cato*:—

Thomas' Massachusetts Spy.

"Do thou, great Liberty, inspire our souls,
And make our lives in thy possession happy,
Or our deaths glorious in thy just defence."

In July 1774, during the operation of the Boston Port Bill, and soon after the landing of four British regiments,

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Franklin's odd device was adopted, representing Great Britain as a dragon, and the colonies as a snake divided into nine parts, with the motto, "join or die." But Boston grew too hot for the patriotic printer, and he had to remove to Worcester on the day of the battle of Lexington. Here the paper continued to be published until 1786; the lack of the stirring revolutionary matter being occasionally supplied by the republication in its columns of entire books, such as Robertson's *America* and Gordon's *History of the Revolution*. But this journal, like so many more, was for a time killed by a tax. The stamp duty imposed in March 1786, though amounting to but two-thirds of a penny, and very speedily repealed, led to the suspension of the *Spy* until April 1788. At that period it was resumed; and it still continues, being the oldest newspaper in Massachusetts.

Numerical strength of the American press at the Revolution.

At the commencement of the struggle for independence in 1775, Massachusetts possessed 7 newspapers, New Hampshire 1 (founded in 1756, and entitled the *N. H. Gazette*), Rhode Island 2, and Connecticut 3; making 13 in all for the New England colonies. Pennsylvania had 8, of which the earliest in date was the *American Weekly Mercury* (No. 1, 22d December 1719); and New York but 3, the oldest of them being the *New York Gazette*, the publication of which had commenced on the 16th October 1725. Up to that period (1725) Boston and Philadelphia were the only towns possessing a newspaper throughout America. In the middle and southern colonies there were (in 1775), in the aggregate, 10 journals, of which Maryland, Virginia, and North Carolina, possessed each 2, South Carolina 3, and Georgia 1. The total number of the Anglo-American papers was 34, and all of them were of weekly publication.

Summary of the New England press.

The *New Hampshire Gazette* still exists, and is the "father" of the American press. In 1810 this State possessed 12 papers; in 1828, 17; in 1840, 27; in 1850 (the date of the last census), 32,—viz., 22 described as "political," and 10 as "miscellaneous." The earliest paper established in Vermont was the *Green Mountain Postboy*, first published in April 1781. In 1850 the number of newspapers was 30; 27 of which are described as "political." Maine possessed in 1850, 29; 4 of them of daily publication. Rhode Island had 13, of which 5 were daily; Connecticut had 28, including 7 daily papers; Massachusetts possessed in 1850 no less than 91 newspapers, with a collective circulation of 222,087 copies, and an aggregate circulation amounting in the year to 46,587,000. Of these, about two-thirds were published in Boston. Of the whole number, 22 were of daily, 4 of tri-weekly, 11 of semi-weekly, and 54 of weekly publication.

Press of Pennsylvania,

Pennsylvania had in 1810, 71 newspapers, and in 1850, 210, with a collective circulation of 338,336 copies, and an aggregate circulation, in the whole year, amounting to 59,717,508 copies.

The *Aurora* was the most notable of the early Philadelphia papers, next to Franklin's *Gazette*. Its hostility to federalism, and to Washington as the main pillar of the federalists, was so violent that, on the termination of his presidency, it sung so loud a *Nunc dimittis* as to excite a riot, in which its printing-office was destroyed. The *Daily National Gazette*, started in 1820, soon became prominent for its union of literature with politics. The total number of journals, political and literary, published in Philadelphia, in 1856, was 76, 12 of which were of daily publication.

and of New York.

In New York, the *Gazette* already mentioned was followed by the *Weekly Journal* (No. 1, 5th November 1733), still memorable for the prosecution for sedition which it entailed on its printer, John Peter Zenger, and for the masterly defence of the accused by Andrew Hamilton. "The trial of Zenger," said Gouverneur Morris, "was the germ of American freedom." Gaines's *New York Mercury* was published from 1752 to 1783. Rivington's *Royal Gazette* was established in 1773, and in the first year of its existence is said to have attained a circulation of 3600. After the Revolution this paper was continued under the title *New York Gazette, and Universal Advertiser*. The first daily newspapers published in the city or State of New York was *The New York Journal and Register*, commenced in 1788. In 1810 the aggregate number of papers published within the State was 66, of which 14 belonged to New York city. Ten years later the city press included 8 daily journals, with an aggregate daily circulation of 10,800 copies. No one paper circulated more than 2000, and but two—the *Evening Post* and the *Commercial Advertiser*—attained that number. Both the papers last named continue to flourish. In 1832 there were 13 daily journals, with a collective daily circulation of 18,200; or, on the average, 1400 to each paper. In 1850 the number of daily papers (according to the census returns) was 51, with an aggregate annual circulation of 63,928,685, which will give an average daily issue of 3942 to each of them.

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Daily papers of New York at various periods.

Penny press of America.

The penny press of America began in New York, and the pioneer was the *Daily Sun* (No. 1, 23d September 1833), written, edited, set up, and worked off, by B. F. Day, a journeyman printer. Its circulation at first was 600 copies. In 1854 its average issue was 36,525 copies. Its success has been described with sufficient significancy as mainly owing to "piquant police reports," at least at the outset. When sold, it fetched L.50,000. The profit arising from its advertisements has been stated by Mr Horace Greeley to amount to L.60 a day. The notorious *New York Herald* is also a penny paper; was started in 1835 (at first at a halfpenny); and its average circulation in December 1854 was 36,158. The *New York Tribune* was established in1851 by Mr Horace Greeley, who is still its editor. Its circulation in 1851 was 19,000 copies, of which somewhat more than half was sold within the limits of the city. It has now a daily circulation of about 29,000 copies, and, in addition, issues as a weekly paper 163,000 copies, irrespectively of certain special issues for California and for Europe. These are amongst the prizes of New York journalism. How numerous the blanks are may be inferred from the statement, that between the years 1820 and 1850, 32 daily newspapers were founded and abandoned.

Elaborate as are the returns given in the United States' census in relation to this subject, they are only to be relied upon for precise information respecting *newspapers* when limited to those of *daily* issue. The classification of the main returns which bear on the matter is headed, "How often issued;" and, although there is a subsidiary classification headed "Character," it fails to elicit even the simple distinction between newspapers and magazines. This classed arrangement comprises—(1.) "Literary and Miscellaneous;" (2.) "Neutral and Independent;" (3.) "Political;" (4.) "Religious;" (5.) "Scientific." If, however, we understand the second division as meaning periodicals of "Neutral and Independent" *politics*, the entire newspaper press of the State of New York in 1850 may be summed up thus:—

General statistics of the newspaper press of New York.

Character	No. of Papers.	Average Circulation.	Aggregate Annual Circulation
"Neutral and Independent" Newspapers.....	15	127,370	37,317,010
Newspapers attached to a political party.....	263	399,755	45,463,015
Total of the Newspaper press.	278	527,125	82,780,025

The total number of newspapers published in Maryland, in 1850 was 40, Delaware had 10, and New Jersey 45. The last-named State had no local paper before the Revolution, although a single number of one had been

Newspapers.

published in 1765, under the title of the *Constitutional Gazette, containing Matters interesting to Liberty, but no wise repugnant to Royalty.* The earliest regular paper was the *New Jersey Gazette*, which began in December 1777. The total number of newspapers in the Middle States at the date of the census (estimated as in the case of New York) may be taken at 583, exclusive of periodicals of a distinctly literary, theological, or scientific nature.

Newspaper statistics of the other Middle States.

In the Southern States, the annals of newspapers, as of so much else, may be far more compactly dealt with than is possible in regard to the Northern and Middle States. Virginia, notwithstanding its precedency, possessed neither newspaper nor printing-office until 1736; so that (as respects one-half at least of the wish) there was once a prospect that the devout aspiration of Sir William Berkley might be realized. "Thank God," said this Virginian governor in 1671, "We have neither free school nor printing-press, and I hope may not have for a hundred years to come." The Virginia papers occasionally present to modern readers figures of Liberty at their head (sometimes with a banner, inscribed "*Drapeau sans tache*"), whilst in the body of the journal comes a string of advertisements headed "Cash for Negroes." Those who love America best may perhaps be apt to think that Sir W. Berkley's words would make as appropriate a motto. This great question apart, several of the Virginia papers have evinced considerable ability and independence of spirit. The earliest journal established in the State was the *Virginia Gazette*, commenced in 1736. The *Richmond Inquirer*, which started in 1804, early attained a leading position. In 1810 the total number of Virginian papers was 23; in 1828, 37; at the census of 1850, 67; with an average total circulation of 56,188 copies. North Carolina, at the last-named date, possessed 37 newspapers, with an average total circulation of 25,439; South Carolina, 29, with a similar circulation of 36,415; Georgia, 26, with 23,346; Florida, 7, with 3500; Alabama, 46, with 25,336.

Newspapers of the Southern States.

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The statistics of the newspaper press of the entire Union may be thus epitomized, so far as respects the two classes designated in the census "Neutral" and "Political:"—

General statistics of the newspaper press of the United States.

States and Territories.	Population.	"Neutral and Independent" Papers.			"Political" Papers.			Totals.		
		No.	Total Circulation.	Aggregate No. of Copies Printed Annually.	No.	Total Circulation.	Aggregate No. of Copies Printed Annually.	No	Total Circulation.	Aggregate No. of Copies Printed Annually.
Maine	583,169	...	.....	.....	29	29,695	2,501,680	29	29,695	2,501,680
New Hampshire	317,976	...	.....	.....	22	32,186	1,673,672	22	32,186	1,673,672
Vermont	314,120	...	.....	.....	27	33,990	2,025,430	27	33,990	2,025,430
Massachusetts	994,514	9	50,700	13,591,000	82	171,387	32,996,800	91	222,087	46,587,800
Rhode Island	147,545	1	2,500	781,500	12	18,075	1,693,650	13	20,575	2,476,150
Connecticut	370,792	...	.....	.....	28	34,916	3,422,432	28	34,916	3,422,432
New York	3,097,394	15	127,370	37,317,010	263	399,755	45,463,015	278	527,125	82,780,025
New Jersey	489,555	1	300	93,900	44	40,144	3,823,138	45	40,444	3,917,047
Pennsylvania	2,311,786	12	70,396	21,908,548	198	267,940	37,808,960	210	338,336	59,717,508
Delaware	91,532	...	.....	.....	8	6,600	374,400	8	6,600	374,400
Maryland	583,034	1	700	8,400	39	31,637	4,196,924	40	32,337	4,205,324
Dist. of Columbia	51,687	1	350	54,600	15	99,437	10,990,736	16	99,787	11,045,336
Virginia	1,421,661	5	4,200	1,251,900	62	51,988	6,698,176	67	56,188	7,950,076
North Carolina	869,039	2	875	113,750	35	24,564	1,457,664	37	25,439	1,571,414
South Carolina	668,507	5	8,300	2,140,400	24	28,115	4,310,980	29	36,415	6,451,330
Georgia	906,185	6	3,046	747,340	20	20,900	1,491,350	26	23,946	2,238,690
Florida	87,445	...	.....	.....	7	3,500	202,800	7	3,500	202,800
Alabama	771,623	1	1,000	313,000	45	24,336	1,889,169	46	25,336	2,202,169
Mississippi	606,526	...	.....	.....	40	26,380	1,519,024	40	26,380	1,519,024
Louisiana	517,762	6	12,000	3,335,100	34	45,522	8,356,224	40	57,522	11,691,324
Texas	212,592	1	1,400	148,400	14	8,350	660,400	15	9,750	808,800
Arkansas	209,897	...	.....	.....	6	3,950	205,400	6	3,950	205,400
Tennessee	1,002,717	2	1,610	503,930	36	33,147	5,138,580	38	34,757	5,642,510
Kentucky	982,405	2	800	250,400	42	55,936	5,245,888	44	56,736	5,496,288
Missouri	682,044	...	.....	.....	42	48,340	5,496,280	42	48,340	5,496,280
Illinois	851,470	1	1,290	403,770	73	51,111	3,384,162	74	52,401	3,787,932
Indiana	988,416	...	.....	.....	84	47,900	3,569,324	84	47,900	3,569,324
Ohio	1,980,329	6	13,485	4,220,805	192	189,304	18,865,282	198	202,785	23,086,087
Michigan	397,654	1	200	26,000	39	28,793	2,556,836	40	28,993	2,582,836
Wisconsin	305,391	...	.....	.....	42	29,236	2,517,487	42	29,236	2,517,487
Iowa	192,214	1	1,200	187,200	25	20,150	1,281,800	26	21,350	1,469,000
California	92,597	4	2,000	626,000	...	.....	.....	4	2,000	626,000
Oregon Territory	13,294	...	.....	.....	1	510	26,520	1	510	26,520
Total	23,112,872	83	303,722	88,022,953	1630	1,907,794	221,844,133	1713	2,211,512	309,868,095

(*Seventh Census of the United States*, 1850 (Washington, 1853), passim; Buckingham, *Specimens of Newspaper Literature*, 2 vols. (Boston, 1850), passim; Coggeshall, *The Newspaper Record* (Philadelphia, 1856), passim; *Life and Works of Franklin*, by Sparks, i. 23, 123, &c.; *Life and Works of John Adams*, ii. 405; *Proceedings of the New York Historical Society* for 1844; *Historical Notices of Newspapers published in North Hampshire*, in *Farmer and Moore's Collection*, iii. 174, seq.; Frothingham, *History of the Siege of Boston*, 31, seq.; *Minutes of Evidence before the Select Committee on Newspaper Stamps* (Evidence of Mr H. Greeley), Q. 2614-2664, 2978-3068, pp. 389-395, 438-448.)

III.—THE NEWSPAPERS OF FRANCE.

Renaudot's Gazette.

The long and eventful annals of French journalism begin with the *Gazette* established by Théophraste Renaudot in 1631, under the patronage of Richelieu, and very probably with his active co-operation. Renaudot was born at Loudon in 1584; studied medicine in Paris, and afterwards at Montpellier, where he took his degree; established himself in the capital in 1612, and soon became conspicuous both within and beyond the limits of his profession. Endowed by nature with great energy and versatility of talent, he seems at an early period of his career to have attracted the attention of the great Cardinal, and to

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have obtained permission to establish a sort of general agency office, under the designation of "*Bureau d'Addresses et de Rencontre.*" An enterprise like this would, perhaps, naturally suggest to such a mind as Renaudot's the advantage of following it up by the foundation of a newspaper. According to some French writers, however, the project was formed by Pierre d'Hozier, the genealogist, who carried on an extensive correspondence both at home and abroad, and was thus in a position to give valuable help; according to others by Richelieu himself. Be this as it may, Renaudot put his hand zealously to the work, and brought out his first weekly number in May 1631. So much, at least, may be inferred from the date (4th July 1631) of the sixth number, which was the first *dated* publication; the five preceding numbers being marked by "signatures" only—A to E. Each number consists of a single sheet (eight pages) in small quarto, and is divided into two parts—the first simply entitled "*Gazette*," the second "*Nouvelles Ordinaires de Divers Endroits.*" For this division the author assigns two reasons—(1.) That two persons may thus read his journal at the same time; (2.) That it facilitates a division of the subject-matter—the *Nouvelles* containing usually intelligence from the northern and western countries, the *Gazette* from the southern and eastern. He commonly begins with foreign, and ends with home news,—a method which was long and generally followed, and which still obtains. Once a month he published a supplement, under the title of *Relation des Nouvelles du Monde reçues dans tout le Mois.* "These monthly *Relations* of mine," he says, "serve to epitomize and to correct the weekly ones. For it is with news as with metals—when they come first from the mine, the metals are mixed with earth. In like manner, news are at the outset usually accompanied by mistakes and misconceptions, from which in a little time they get separated, just as the metals lose their dross in the furnace. Then you get them pure."

In October 1631, Renaudot obtained letters-patent to himself and his heirs, conferring the exclusive privilege of printing and selling, where and how they might please, "the gazettes, news, and narratives of all that has passed or may pass within and without the kingdom—" . . . . [In the beginning of this document he had been designated "Master and General Intendant of the Address Offices of the Kingdom;" and these offices are directly connected with the *Gazette* by the addition, after the words we have quoted, of what follows—] "conferences, prices-current of merchandise, and other printed matter of the said offices (*autres impressions des dits bureaux*)." At the end of the year, he collected his thirty-one numbers into a volume, and published them under the title, *Recueil des Gazettes de l'Année* 1631; prefixing also a preface to the public, and a dedication to the king. In the former he says,—

"The publication of gazettes is in truth new; but this novelty may win for them a favour which they will easily preserve. They will be maintained for their utility, both to the community and to individuals;—to the community, by preventing those false reports which often serve to kindle turmoils and seditions; to individuals, by enabling every man to adjust his business according to the needs of the time. Thus the merchant will not betake himself for traffic to a besieged or ruined city, nor will the soldier seek for service in a country which is at peace,—to say nothing of the advantage they will bring to those who have to write to friends, whose curiosity they had heretofore to satisfy with news, often invented for the occasion, or founded on the guess-work of mere hearsay." . . . . "The difficulties," he adds, "which I mention as attendant on the composition of my *Gazettes* are not put forward for the glorification of my work, but as an excuse for my style, if it does not always correspond with the dignity of my themes. . . . . Captains wish to have news of battles and sieges every day; lawyers to have law reports; devout persons to meet the names of favourite preachers and confessors. Some people, who understand nothing of the secrets of the court, wish to have them exposed at full length. Others are angry if their names do not meet the king's eye in the *Gazette*, for having bought the reversion of some unimportant office, or for having safely conveyed a state parcel. . . . . Some attach value to nothing but flowery language; others would have my narratives resemble a bare skeleton. . . . . Can you then, my reader, deny me your pity, or withhold your pardon, if my pen fail to please everybody, hold it as I may; any more than could the peasant and his son, in the fable, although they travelled first singly, and then together,—at one time a-foot, and at another on the ass? . . . . Yet I should deceive myself were I to hope to curb your censure by my remonstrances. I cannot do it, and ought not, reader, if I could. The liberty to find fault is not the least of the pleasures attendant on reading of this sort; and it is for your pleasure that this novelty has been invented. Enjoy, then, at your ease your French liberty; and let every one say boldly that he would take away this, or change that, and that he could have done much better. I admit it. In one thing only I will yield to nobody—in the search after truth, though I will not vouch for its constant attainment."

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Renaudot's assailants were numerous, and made full use of "French liberty." Many, too, were the parodies by which it was sought to throw ridicule upon his enterprise. But he steadily pursued his course, rarely noticed his assailants, and at his death in October 1653, left the *Gazette* to his sons in flourishing circumstances. In 1752 the title "*Gazette de France*" was first used. Under this designation it continued to appear until the 24th August 1848. During the five memorable days which followed that date it was suspended; on the 30th it was resumed as *Le Peuple Français, Journal de l'Appel à la Nation;* and again modified on the 14th September to *L'Etoile de la France, Journal des Droits de Tous.* On the 25th October it became *Gazette de France, Journal de l'Appel à la Nation;* and under this title it still continues to appear. A complete set extends to upwards of 300 volumes, of which 189 are in quarto, and the rest in folio. It scarcely need be added that such a set forms a collection of great value, not only for the history of France, but for that of Europe generally.

Suspension of the Gazette de France in 1848, and its subsequent resumption.

We pass over a group of *Couriers* (*Le Courrier Français, Le Courrier de la Cour, Le Courrier Burlesque, Le Courrier Bourdelais,* &c.), which properly form part of the extraordinary collection of pamphlets usually termed *Mazarinades.* Most of these *Couriers* belong to the year 1649, but they are not serial newspapers. They come within the same category as the English news-pamphlets mentioned in a preceding section of this article.

In 1650, Paris had its newspaper in verse. Loret, the "courtier-poet," as he has been called, began this flimsy but amusing, and now not uninstructive periodical, for the gratification of his patroness, Mademoiselle de Longueville.

Loret's Muse Historique, or Gazette du Temps, en Vers Burlesques.

"Pour complaire à ses volontés,
Et mieux meriter ses bontés."

But the new Gazetteer was too witty, and too incisive in his stroke, to be long confined to the narrow though brilliant circle of the Hotel de Longueville. MS. copies were obtained, sometimes surreptitiously, sometimes by dint of pertinacious application. At length, after it had circulated from hand to hand for nearly two years and a half, some numbers were furtively printed under the title *La Gazette du Temps, en Vers Burlesques.*

"Des debiteurs de faux papiers,
Pires cent fois que des fripiers,
Faisaient imprimer ses gazettes,
Sans craindre ni loi ni syndic
Pour en faire un lâche trafic."

The poor poet was fain to follow the example. He consoles himself by the reflection that the copies in MS. were always faulty, and gravely assures his readers that "printing is an excellent invention for producing simultaneously several copies of a work." Resuming his verse, however, he proceeds:—

"Mais sache, lecteur débonnaire,
Encor que des mains du rimeur
Cette gazette épistolaire
Passe en celles de l'imprimeur,

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Qu'elle n'en est pas plus commune;
Car, sans abus ni fraude aucune,
Il doit observer cette loi
De n'en tirer chaque semaine,
Qu'une unique et seule douzaine,
Tant pour mes amis que pour moi;
Après cela point de copie,
En dût-on avoir la pepie."

The usual title of each Gazette, as printed by the author, is *Lettre en vers à Son Altesse Mlle. de Longueville;* but in 1656 he collected them under the title *La Muse Historique, ou Recueil des Lettres en Vers écrites à S. A. Mlle. de Longueville, par le Sieur Loret.* Livre premier. Dedié au Roi (Paris, 1656, 4°). He continued the task almost until the day of his death, in April 1665. His last letter ends with this sad couplet:—

"Le vingt-huit Mars j'ai fait ces vers,
Souffrant cinq ou six maux divers."

The first complete edition appeared in 1658; and the words "Contenant les nouvelles du temps," are added to the title above mentioned.

Loret's *Gazette* will always have interest in the eyes of students, who care less for the "dignity" of history than for the fidelity of its local colouring, and the animation of its backgrounds, if we may so speak. It were as vain to look there for any deep appreciation of the events of those stormy times as for state papers or notes of diplomatic conferences. But it abounds in vivid portraits of the men and manners of the day. It paints rudely, yet to the life, the Paris of the Fronde, with all its effervescence and depression, its versatility and fickleness, its cowardice and its courage.

Mercure Galant, afterwards Mercure de France.

Of the *Mercure Galant*, established by Donneau de Visé in 1672, it may be said that it sought to combine the qualities of the *Gazettes*, both grave and gay. Like the former, it contained the state news and court circulars of the day. Like the latter, it amused its readers with satirical verses, and with sketches of men and manners, which, if not always true, were at least well invented. Reviews and sermons, law pleas and street airs, the last reception at the academy, and the last new fashion of the milliners, all find their place; nor can it be denied that the writer has redeemed the pledge implied in these words of his prospectus:—"If my letters" (for, like Loret, he cast his news into the epistolary mould) "be preserved, . . . they may hereafter become useful memorials, in which will be found many things not elsewhere to be met with." De Visé carried on his enterprise during more than thirty years, and at his death it was continued by that Rivière du Fresny, who has his little niche in Voltaire's portrait gallery:—

"Et Du Fresny, plus sage et moins dissipateur,
Ne fût pas mort de faim,—digne mort d'un auteur."

The successor of this worthy, Lefevre de Fontenay, altered the title to *Mercure de France* (a designation retained, with some slight modification, until 1853). The *Mercure* passed through many other hands before it came into those of Panckoucke, at the eve of the Revolution. Amongst its more conspicuous writers, immediately before this change, had been Raynal and Marmontel. The latter, indeed, had for many years been its principal editor, and in his Memoirs has left us a very interesting record of the views and aims which governed him in the performance of an arduous task. And he there narrates the curious fact, that it was Madame de Pompadour who invented the plan of giving pensions to eminent men of letters out of the profits of the *Mercure*. To one of Marmontel's predecessors the "privilege," or patent, had been worth more than L.1000 sterling annually. This revenue was now to be shared amongst several, and to become a means of extending royal "patronage" of literature at a cheap rate. Marmontel's account of his conversation with Pompadour as to the selection of the patronized, is not the least amusing thing in those admirable *Memoirs*.

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It is, too, to this pension-scheme that we owe the *Contes Moraux*. Marmontel, who had long before lost his "patent" by an act of high-minded generosity, continued to share in the composition of the literary articles with Chamfort and La Harpe, whilst Mallet du Pan became the most prominent of its political writers. In 1789 the latter published a series of remarkable articles on the well-known book of De Lolme. In the same year he penned some comments on the "Declaration of the Rights of Man," very distasteful to violent men of all parties, but which forcibly illustrate the pregnant truth they begin with:—"The Gospel has given the simplest, the shortest, and the most comprehensive 'Declaration of the Rights of Man,' in saying, *Do unto others as you would that they should do unto you.* All politics hinge upon this."

The Mercure during the Revolution.

In 1790 the sale of the *Mercure* rose very rapidly. It attained for a time a circulation of 13,000 copies. Mirabeau styled it in debate, "the most able of the newspapers." Great pains were taken for the collection of statistics and state papers, the absence of which from the French newspaper press had theretofore helped to depress its credit, as compared with the political journalism of England, and even of Germany. But in proportion as the Revolution marched on with more rapid strides towards an unchecked democracy, Mallet Du Pan evinced more and more unmistakably his rooted attachment to a constitutional monarchy. And, like so many of his compatriots, he soon found the tide too strong for him. The political part of the *Mercure* changed hands, and after the 10th August 1792 its publication was suspended.

All this time the *Moniteur* (*Gazette Nationale, ou le Moniteur Universel*) was under the same general management as the *Mercure Français* (so the title had been altered in 1791). The first idea, indeed, of this famous official journal appears to have been Panckoucke's, but it did not firmly establish itself until he had purchased the *Journal de l'Assemblée Nationale*, and so secured the best report of the debates. The *Moniteur*, however, kept step with the majority of the assembly, the *Mercure* with the minority. So marked a contrast between two journals, with one proprietor, gave too favourable a leverage to the republican wits not to be turned to good account. Camille Desmoulins depicted him as Janus,—one face radiant at the blessings of liberty, the other plunged in grief for the epoch that was rapidly disappearing. "When M. Panckoucke," he said, "leaves the printing-office of his *Moniteur Universel*, he is an ardent patriot; when he enters the editor's room of his *Mercure de France*, a sudden change comes over him, converting the patriot of the instant before into a furious aristocrat."

Contrast between the opinions of Panckoucke's Mercure and those of his Moniteur.

When resumed, after a very brief interval, the *Mercure Français* became again *Mercure de France;* its political importance diminished, whilst its literary worth was enhanced. During the later days of the Revolution, and under the imperial domination, its roll of contributors included the names of Geoffroy, Ginguené, Morellet, Lacretelle, Fontanes, and Chateaubriand. The statesman last named brought upon the *Mercure* another temporary suppression in 1807, by words which were in true unison with the noblest deed of his chequered career,—that retirement, namely, from the imperial service which he resolved and effected on the day that the news of the execution of the Duke of Enghien reached him, being the day after he had been appointed by Napoleon a minister plenipotentiary. A few of these weighty words must find room. What may seem pedantic in their style is, it will be remembered, the local colouring of the time.

Suppression of the Mercure for an article by Chateaubriand.

. . . "When in the silence of despair no sound makes itself heard, save the chain of the slave and the voice of the informer,—when all tremble before the tyrant, and it becomes as dangerous to obtain his favour as to incur his displeasure, then arises the historian

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who embodies the vengeance of the nations. It is in vain that Nero prospers. Tacitus is already born within the bounds of the empire. Beside the ashes of Germanicus, he grows up to man's estate, unknown and unnoticed; and already has a righteous Providence placed in the hands of an obscure child the fame of the master of the world. If the part which the historian is called to play upon the world's stage be a noble one, yet it is often dangerous; but he ministers at an altar which, like that of honour, although abandoned, claims its sacrifice; the god is not annihilated because the temple is deserted."

Thus it chanced that alike under the brilliant despotism of Napoleon, and under the crapulous malversation of Louis XV., the management of the *Mercure* was revolutionized for protests which conferred honour upon the journal, no less than upon the individual writers who made them. Resumed by other hands, the *Mercure* continued to appear until January 1820, when it was again suspended. In the following year it re-appeared as *Le Mercure de France au dix-neuvième Siècle*, and in February 1853 it finally ceased. A complete set extends to no fewer than 1611 volumes.

Journal de Paris.

The only other newspaper of a date anterior to the Revolution which needs to be noticed here, is the *Journal de Paris*, which was commenced on new year's-day of 1777. It had but a feeble infancy, yet lived, as ricketty children sometimes do, for half a century. Its early volumes appear so insipid to a nineteenth century reader, that he wonders what can have been the cause of its occasional bickerings with the police. Its tameness, however, did not save it from sharing in the "suspensions" of its predecessors. After the Revolution, such men as Garat, Condorcet, and Regnaud de St Jean d'Angély appear amongst it contributors, but those of earlier date were intensely obscure. Its period of highest prosperity may be dated about 1792, when its circulation is said to have exceeded 20,000.

The Nouvelles à la Main.

The police adventures of the writers of the MS. News Letters, or *Nouvelles à la Main*, were still more numerous; and if we may judge from the copious specimens of these epistles which yet survive, must also not unfrequently have arisen from lack of official employment, rather than from substantial provocation. Madame Doublet de Persan, the widow of a member of the French Board of Trade, was a conspicuous purveyor of news of this sort. For nearly forty years, daily meetings were held in her house, at which the gossip and table-talk of the town were systematically (and literally) *registered;* and weekly abstracts or epitomes were sent into the country by post. Piron ("Piron qui ne fût rien, pas même academicien"), Mirabaud, Falconet, D'Argental (the "ame damnée" of Voltaire, as Marmontel called him), and, above all, Bachaumont, were prominent members of the "society," and each of them is said to have had his assigned seat beneath his own portrait. The lady's valet de chambre appears to have been editor *ex officio;* and as he occasionally suffered imprisonment, when offensive news-letters had been seized by the police, so responsible a duty was doubtless "considered in the wages." News and anecdotes of all kinds,—political and literary, grave, gay, or merely scandalous,—were all admitted into the *Nouvelles à la Main;* and their contents, during a long series of years, form the staple of those *Mémoires Secrets pour servir à l'Histoire de la République des Lettres*, which extend to 36 volumes, have been frequently printed (at first with the false imprint,—Londres: John Adamson, 1777–89), and are usually referred to by French writers as the *Mémoires de Bachaumont.*

The newspapers of the Revolution.

The journalism of the first Revolution has been the theme of many bulky volumes, and their number is still on the increase. Like all modern insurrections, in which legitimate and long repressed aspirations have been commingled with visionary but fondly-cherished dreams of a world wherein luxury should precede labour, and vice imperceptibly transmute itself into virtue, the period of the Revolution was marvellously fertile in every kind of intellectual effort. The simple recital of the mere titles of the newspapers which then appeared throughout France fills more than forty pages of larger dimensions than those which the reader has now before him. It is obvious, therefore, that a very casual glance at this part of our subject is all that can here be given to it.

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When at least one half of the French people was in a ferment of hope or of fear at the approaching convocation of the States-General, most of the existing newspapers were still in a state of torpor. Long paragraphs, for example, about a terrible "wild beast of the Gevaudan"—whether wolf or bear, or as yet nondescript, was uncertain—were still current in the Paris journals at this momentous juncture; just as the "enormous gooseberry" fills up, at the dull season of the year, a blank in an English, or the "marvellous sea-serpent" a blank in an American, country paper. Mirabeau was amongst the foremost to supply the popular want. His *Lettres à ses Commettants* began on the 2d May 1789, and with the twenty-first number became the *Courrier de Provence.* Within a week Maret (afterwards Duke of Bassano) followed with the *Bulletin des Séances de l'Assemblée Nationale*, and Lehodey with the *Journal des États Généraux.* In June, Brissot de Warville began his *Patriote Français.* Gorsas published the first number of his *Courrier de Versailles* in the following month, from which also dates the famous periodical of Prudhomme, Loustalot, and Tournon, entitled *Révolutions de Paris*, with its characteristic motto,—"Les grands ne nous paraissent grands, que parce que nous sommes à genoux; levons nous!" A month later, Barère and Louvet began the *Journal des Débats*, and Marat the *Ami du Peuple* (which at first was called *Le Publiciste Parisien*). The *Moniteur Universel* (of which we have spoken already), was first published on the 24th November, although numbers were afterwards printed bearing date from the 5th May, the day, it will be remembered, on which the States-General first assembled. Camille Desmoulins also commenced his *Révolutions de France et de Brabant* in November 1789. The *Ami du Roi* was first published in June 1790; *La Quotidienne* in September 1792.

Of all these prominent journals the *Moniteur* and the *Débats* alone have survived until now. A few of them lasted until 1794 or 1795; one continued until recently; but most of them expired either in the autumn of 1792, or with the fall of the party of the Gironde in September 1793. In some of these papers the energy for good and for evil of a whole lifetime seems to be compressed into the fugitive writings of a few months. Even the satirical journals which combated the Revolution with shafts of ridicule and wit, keen enough after their kind, but too light to do much damage to men who were terribly in earnest, abound with matter well deserving the attention of all students desirous of a thorough knowledge of the period. Of this class those more especially in which Peltier was concerned—as, for example, the *Actes des Apôtres*, the *Paris*, and *L'Ambigu*—depict the Royalists themselves vividly enough, whatever may be the amount of credit due to their delineations of their foes. Peltier's name is now best remembered for the famous trial which his incessant attacks upon Napoleon entailed on him. His fondness for drawing comparisons between the "yellow emperor" and the "black emperor," greatly to the advantage of the Haytian, so pleased the latter as to bring him very substantial and acceptable marks of gratitude, in the shape of numerous bags of coffee and hogsheads of sugar, which were speedily converted into cash for the gratification of tastes little in harmony with the ordinary resources of an exiled journalist. The sad contrast between the gratitude of the negro monarch and the indifference of the government of the Restoration towards services which had been long and faithful, prompted an epigram, which unfortunately alienated his distant benefactor:—

The light skirmishers of the revolutionary press.

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"Mon roi me traite comme un nègre,
Mais mon nègre, à son tour, me traite comme un roi."

So that the poor author died, if we accept the dictum of Voltaire, an appropriate death, in a garret, in the spring of 1825.

The consular government began its dealings with the press by reducing the number of political papers to thirteen. At this period the original number of daily journals had been nineteen, and their aggregate provincial circulation, apart from the Paris sale, 49,313, or 2600 each, on the average.

Under Napoleon, the *Moniteur* was the only political paper that was really regarded with an eye of favour. Even as respects the nation at large, the monstrous excesses into which the revolutionary press had plunged left an enduring stigma on the class. When M. Bertin acquired the *Journal des Débats* from Baudouin, the printer, for 20,000 francs, he had to vanquish popular indifference on the one hand, as well as imperial mistrust on the other. The men he called to his aid were Geoffroy and Fievée; and by the brilliancy of their talents, and the keenness of his own judgment, he converted the *Débats* into a paper having 32,000 subscribers, and producing a profit of 200,000 francs a year. When a special censorship was about to be imposed on it, in 1805, at the instance of Fouché, a remarkable correspondence took place between Fievée and Napoleon himself, in the course of which the emperor wrote, that the only means of preventing a newspaper from suspension was "to avoid the publication of any news unfavourable to the government, until the truth of it is so well established that the publication becomes needless, the bad news being in everybody's mouth." ("Toutes les fois qu'il parviendra une nouvelle défavorable au gouvernement, elle ne doit être publiée, jusqu'à ce qu'on soit tellement sûr de la vérité qu'on ne doive plus la dire, parce qu'elle est connue de tout le monde.") The censorship was avoided, but Fievée had to become the responsible editor, and the title was altered to *Journal de l'Empire*—the imperial critic taking exception to the word *Débats* as "inconvenient." The old title was resumed in August 1815. The revolution of July did but enhance the power and the profit of the paper. It has held its course with dignity as well as ability amidst recent perils, and may still be said, in the words which Lamartine applied to it in an earlier day, to have "made itself part of French history."

The Journal des Débats.

Shortly before the *Journal de l'Empire* became again the *Journal des Débats* (in 1815), a severance occurred amidst both the writers and subscribers, which led to the foundation of the *Constitutionnel*, which for a short time bore the title of *L'Indépendent*. The former became, for a time, the organ of the Royalists, *par excellence*, and furnished its due quota of "*ogre de Corse*" and the like; the latter, the leader of the opposition. In 1824, however, both were in conflict with the government of the day. At that date the statistics of the Paris press were thus stated, in a secret report addressed to the ministry:—

Statistics of the Paris press in 1824.

Government Press.		Opposition Press.	
Name of Paper.	Circulation.	Name of Paper.	Circulation.
1. Journal de Paris.	4,175	1. Le Constitutionnel..	16,250
2. L'Etoile	2,749	2. Journal des Débats.	13,000
3. Gazette de France	2,370	3. La Quotidienne.....	5,800
4. Le Moniteur.....	2,250	4. Le Courier Français	2,975
5. Le Drapeau Blanc	1,900	5. Journal de Commerce	2,380
6. Le Pilote	900	6. L'Aristarque	925
Total.....	14,344	Total	41,330

The rapid rise of the *Constitutionnel* was due partly to the great ability and influence of Étienne, of Beranger, and of Saint Albin (who had been secretary to Carnot, in his ministry of 1815), all of whom co-operated in its early editorship; and partly to its sympathy with the popular reverence for the memory of Napoleon, as well as to the vigorous share it took in the famous literary quarrel between the Classicists and Romanticists (although in that quarrel it took what may now be called the side of the vanquished). Its part in bringing about the revolution of 1830 raised it to the zenith of its fortunes. For a brief period it could boast of 23,000 subscribers, at 80 francs a year. But the invasion of cheap newspapers, and that temporary lack of enterprise which so often follows a brilliant success, lowered it with still greater rapidity. When the notorious author of the *Mémoires d'un Bourgeois*, Dr Véron, purchased it, the sale had sunk to 3000. Véron gave 100,000 francs for the wretched *Juif Errant* of Sue, and the Sue fever rewarded him for a while with more than the old circulation. Recently it has been under the editorship of Césena, Granier de Cassagnac, and La Guéronnière; and it need scarcely be added that its glory has departed.

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The rise and fall of the Constitutionnel.

The cheap journalism of Paris began in 1836 (1st July), with the famous journal of M. De Girardin, *La Presse*, followed instantly by *Le Siècle*, under the management of M. Dutacq. The first-named journal attained a circulation of 10,000 copies within three months of its commencement, and soon doubled that number. The *Siècle* prospered even more strikingly, and in a few years had reached a circulation (theretofore without precedent in France) of 38,000 copies.

La Presse and Le Siècle.

The rapid rise of the newspaper press of Paris will be best appreciated, if we tabularize the number of stamps issued,—as has been already done for the British newspapers:—

Years.	No. of Stamps.
1828	28,000,000
1836	42,000,000
1843	61,000,000
1844	62,283,200
1845	65,000,000
1846	79,000,000

At the date last mentioned the relative position of the twenty-six daily papers stood thus:—

Name of Paper.	Circulation.
*Le Siècle	31,000.
*La Presse	Between 20,000 & 25,000.
*Le Constitutionnel.	
*Journal des Débats	Between 10,000 & 15,000.
L'Epoque	
Le National	Between 3000 and 5000.
*Le Charivari	
*Gazette de France	
Le Commerce	
La Quotidienne	
*La Patrie	
*L'Estafette	
L'Esprit Public	
*L'Univers	
Moniteur Parisien	Betwn. 2000 and 3000
La Reforme	
L'Echo Français	
Courrier Français	
Democratie Pacifique	
Le Droit	
*Gazette des Tribunaux	
L'Entr'acte	
Journal de Paris	Betw. 500 and 2000
Le Messager	
Le Corsaire-Satan	
La France	

The *Moniteur* does not here appear, for the reason that the greater part of its circulation is official and gratuitous. It is just to add, that the vast disparity of circulation shown by this table (as for example, between journals like *Le National* and *Le Siècle*), affords no test whatever of public opinion, either as to their politics, or their ability. The business was simply an affair of story-telling. The most trashy novelist, who had for a moment won the public ear, was able (for his brief period) to dictate terms to the shrewdest and most experienced proprietor of a newspaper. Thus it was that M. Dumas was enabled to make a contract with the proprietors of *La Presse* and *Le Constitutionnel* jointly, which brought him in 64,000 francs a year; and then to sell the right of reprinting his tales, for

Rise of the feuilleton.

Newspapers.

a round sum, to a certain M. Troupenas, who, according to the Paris wits, killed himself by a brain fever, brought on in a vain attempt to divide M. Dumas' lines into half lines, in order to increase the number of volumes.[1]

Newspaper flood of 1848.

To a great extent, the inundation of newspapers which followed the revolution of February 1848, was but a parody—and a very poor one—on the revolutionary press of 1793. Most of them, of course, had very short lives. When Cavaignac took the helm he suppressed eleven journals, including *La Presse* and *L'Assemblée Nationale*. The former had at this period a circulation of nearly 70,000, and its proprietor, in a petition to the National Assembly, declared that it gave subsistence to more than 1000 persons, and was worth in the market at least 1,500,000 francs. In August, the system of suretics was restored. On the 13th June 1849 the present Emperor, as "President of the Republic," suspended *Le Peuple, La Révolution Démocratique et Sociale, La Vraie République, La Démocratie Pacifique, La Réforme*, and *La Tribune des Peuples*. On the 16th July 1850 the Assembly passed what is called the "Loi Tinguy," by which the author of every newspaper article on any subject, political, philosophical, or religious, was bound to affix his name to it, on penalty of a fine of 500 francs for the first offence, and of 1000 francs for its repetition. Every false or feigned signature was to be punished by a fine of 1000 francs, "together with six months' imprisonment, both for the author and the editor." The practical working of this law lies in the creation of a new functionary in the more important newspaper offices, who is called "secretaire de la rédaction," and is, in fact, the scape-goat *ex officio*. In February 1852 all the press laws were incorporated, with increased stringency, into a "Décret organique sur la presse." The stamp duty for each sheet was fixed at six centimes, within certain dimensions, and a proportional increase in case of excess. By this law the newspapers are at present governed; and their price—*La Presse* only excepted—has returned to the tariff of 1835. The existing number of daily papers in Paris is but fourteen (the *Moniteur* included), and is made up of those to which an asterisk is prefixed in the preceding table, with the addition of *L'Assemblée Nationale, Le Pays, L'Union*, and the *Journal des Faits*. The relative circulation of the six leading papers recently stood thus:—(1.) *Siècle;* (2.) *Presse;* (3.) *Constitutionnel;* (4.) *Patrie;* (5.) *Débats;* (6.) *Assemblée Nationale*. The number of provincial papers exceeds 500, but scarcely ten of them possess importance of any kind.

Law of 1850 abolishing anonymous articles in newspapers.

Press law of 1852.

(Hatin, *Histoire du Journal en France*, 2d edit., 1853, passim; Gallois, *Histoire des Journaux et Journalistes de la Révolution*, 2 tom., passim; Marmontel, *Mémoires*, i. 277-291; Morellet, *Éloge de Marmontel*, 11, 12; Chateaubriand, *Mémoires d'outre Tombe*, iii., § 1, 24, seq.; *Mémoires of Mallet Du Pan*, i. 29, seq.; *Biographie Universelle*, articles "Bachaumont," "Donneau," "Doublet," "Garat," "Loret," "Panckoucke," "Renaudot;" *Bulletin du Bibliophile*, N.S., vii. 855–866; Lamartine, *Histoire de la Révolution de* 1848; *Bibliothèque Impériale—Catalogue de l'Histoire de France*, iv. 345–569, 1857, 4to.

IV.—NEWSPAPERS OF GERMANY AND OF NORTHERN EUROPE.

Early German papers.

No real serial newspaper can be shown to have existed in Germany of earlier date than 1615, when Egenolph Emmel, a bookseller of Frankfort, established one, of which little more is now known, than that in the following year his example was imitated, doubtless with some improvement, by the foundation of the *Frankfurter Oberpostamtszeitung*. Fulda appears to have been the next German town to possess a newspaper; then Hildesheim (1619), and Herford (1630). In the course of the century almost all German cities of the first rank possessed their respective journals. The earliest in Leipsic bears date in 1660. The *Hamburgischer Correspondent* dates from 1714, and was almost the only German newspaper which really drew its foreign news from "our own correspondent." Berlin had two papers, those of Voss and of Spener, both of which are still published. They possessed in their earlier career some literary value, but were politically null. Some half-dozen papers which glimmered in the surrounding darkness were the reservoirs whence the rest replenished their little lamps. On the whole, it may be said that the German newspapers were of very small account, until after the outbreak of the French Revolution. Nor, indeed, can any journal of a high order be mentioned of prior appearance to the *Allgemeine Zeitung*, founded by Cotta (at first under the title of *Neueste Weltkunde*) in 1798, and which is still at the head of the political press of Germany. Posselt was its first editor, but his want of nerve—perhaps of physical health—hindered the application of his high powers to political journalism; and to this constitutional impediment another was added, which is very honourable to his memory. His articles gave offence to the Austrian court, and the paper had to change both its title and its place of publication. It had been commenced at Tübingen, and removed to Stuttgardt. It was now transferred to Ulm, and again from thence to Augsburg. It was Cotta's aim to make this the organ of statesmen and publicists, to reach the public through the thinkers, to hold an even balance between the rival parties of the day, and to provide a trustworthy magazine of materials for the historians to come; and, in the course of time, his plan was so worked out as to raise the *Allgemeine Zeitung* into European fame. L. F. Huber succeeded Posselt in the editorship. He was of a family which had already distinguished itself in that kind of literary enterprise which more especially aims at familiarizing to the minds of one country the great works and the prevailing thought of other countries. He died whilst yet in the prime of life, but not before he had rendered good service. Stegmann, Kolb, Mebold, and Altenhöfer have successively been the chief editors since Huber's death. Cotta was also the founder, at various periods, of the *Morgenblatt*, which became famous for its critical ability and tact; of *Vesperus;* of *Das Inland;* of *Nemesis;* of the *Oppositionsblatt* of Weimar (for a time edited by Bertuch); and even of the *Archives Parisiennes*. His ventures were not, of course, uniformly successful in this or in any other of the many spheres of his activity, but it is rare that men of like enterprise have made so few failures. Whilst French influence was dominant in Germany, the German papers were naturally enough little more than echoes of the Parisian press. But amidst the excitements of the "war of liberation" a crowd of new journals appeared. Niebuhr began a *Preussische Correspondent;* Görres undertook the *Rheinische Mercur;* Wetzel, somewhat later, the *Frankische Mercur*, published at Bamberg; Friedrich Seybold the *Neckarzeitung*. Some of these journals lasted but two or three years. Most of the survivors fell victims to that resolution of the Diet (20th September 1819) which subjected the newspaper press, even of countries where the censorship had been formally abolished, to police superintendence of a very stringent kind.

Newspapers.

The Hamburgischer Correspondent.

Foundation of the Allgemeine Zeitung.

Other journals founded by Cotta.

Impulse given to German journalism by the war of liberation.

The aspirations for some measure of freedom which burst forth again under the influences of 1830 led to the establishment of such papers as Siebenpfeiffer's *Westbote;* Loh-

[1] The following is a literal and *lineal* specimen of the dialogue of *Les Trois Mousquetaires*, as published in *Le Siècle*:—

"*Mousq.*—'Eh bien?'
Valet.—'Rien.'
M.—'Rien!'
V.—'Rien.'
M.—'Comment?'
V.—'Rien, vous dis-je.'
M.—'C'est impossible,'" &c.

Newspapers.

bauer's *Hochwächter;* Wirth's *Deutsche Tribune;* Eisenmann's *Baierische Volksblatt; Der Freisinnige* of Rotteck and Welcker; and many more of much freer utterance than had theretofore been heard in Germany. This led, in the ordinary course, to new declarations in the Diet against the license and revolutionary tendencies of the press, and to "regulations" of a kind which will be sufficiently indicated by the mention of one, in virtue whereof no editor of a suppressed journal could undertake another journal, during the space of five years, within any part of Germany. It need hardly be added that few of the newspapers of 1830 saw the Christmas of 1832. Very gradually, after 1840, some of the older journals—and amongst the number the patriarch of all, the *Frankfurter Oberpostamtszeitung*—plucked up courage enough to speak out a little; and some additional newspapers were again attempted. Amongst those which acquired deserved influence were Brockhaus' *Deutsche Allgemeine Zeitung*, the advocate of free trade and of a moderate liberalism, and possessing a large circulation in Northern Germany; the *Deutsche Zeitung*, edited by Gervinus, at Heidelberg (July 1847); and the *Dorfzeitung*, published at Hildburghausen. The stirring events of 1848 called forth in Germany, as in so many other countries, a plentiful crop of political instructors of the people, many of whom manifestly lacked even the capacity to learn, and vanished almost as suddenly as they had appeared. But it is undeniable that a marked improvement in the ability and energy of the German political press may be dated from this period, and bids fair to continue, despite all impediments.

Crusade of the Diet against the German press.

The German press subsequently to 1840.

Statistics of the German press in 1849.

In 1833 the number of German newspapers of all kinds, popular journals (Volksblätter) included, but without reckoning periodicals devoted to literature or science, had amounted to but 335, or thereabout; in 1849 this number had increased to 1551, and their geographical distribution was as follows:—

States.	No. of Papers.	States.	No. of Papers.
1. Anhalt	10	16. Lübeck	4
2. Austria	74	17. Luxemburg	4
3. Baden	55	18. Mecklenburg	22
4. Bavaria	127	19. Nassau	13
5. Bremen	18	20. Oldenburg	8
6. Brunswick	9	21. Prussia	632
7. Frankfort	17	22. Reuss	11
8. Hamburg	24	23. Saxony	183
9. Hanover	32	24. Saxon Duchies	44
10. Hesse-Cassel	22	25. Schaumburg-Lippe	2
11. Hesse-Darmstadt	34	26. Schleswig	5
12. Hesse-Homburg	4	27. Schwartzburg	12
13. Hohenzollern	4	28. Waldeck	2
14. Holstein	17	29. Wurtemberg	67
15. Lippe-Detmold	4		

In addition to these, but included in our total of 1551, 77 German newspapers were published in the Swiss cantons, and 14 in the Baltic provinces of Russia. Many of those reckoned in this enumeration have ceased to appear, but others have taken their places; and the total number in 1855 was estimated to be a little above 1600.

The newspaper press in the Austrian dominions.

At the beginning of 1840 the whole number of Austro-German and Austro-Hungarian periodicals, of all sorts, was under 100; of which but 22 were (after a fashion) political newspapers; and of these nearly all drew their materials and their inspiration from the official papers of Vienna (*Wiener Zeitung* and *Oestreichischer Beobachter*). These two were all that appeared in the capital. Agram, Pesth, Presburg, Limburg, and Prague had each two. No other city had more than a single journal, and that one a nullity, in the sense in which newspapers were regarded in France, and are still regarded in Britain or America. In 1846 the aggregate number of periodicals had grown to 155, of which 46 were political, but political only in the character of mere conduit-pipes for intelligence "approved of" by the government. What sort of journalists were likely to grow up in these Viennese leading-strings may be easily imagined. But it would have been impossible to have conceived beforehand the ludicrous exhibition of their talents which these writers made, when the short-lived freedom of the press burst upon them like a thunder-cloud in March 1848. Yet here, too, as elsewhere, some good seed was cast into the ground, which no busy enemy has been able quite to root up, and which has already produced the earnest of a harvest to come. In 1855 the number of political papers published throughout the entire territory, at present under Austrian government, the Italian provinces excepted, was 57. Their distribution and languages were respectively as follows:—

Newspapers.

Cities.	Number of Newspapers.	Languages.							
		German.	Magyar.	Polish.	Czeckish.	Croatian.	Servian.	Sclavic.	Roumanian.
Vienna	19	19	...	..	...	...	...	...	...
Lintz	1	1	...	...	...	...	...	...	...
Salzburg	2	2	...	...	...	...	...	...	...
Gratz	1	1	...	...	...	...	...	...	...
Klagenfurth	1	1	...	...	...	...	...	...	...
Laybach	1	1	...	...	...	...	...	..	...
Trieste	3	1 [In addition to two in Italian.]							
Prague	4	3	...	...	1	...	...	...	...
Brunn	3	2	...	...	1	...	...	...	...
Olmutz	1	1	...	...	...	...	..	...	...
Troppau	1	1	...	...	...	...	...	...	...
Innsbruck	4	4	...	...	...	...	...	...	...
Pesth	4	2	2	...	...	...	...	...	...
Presburg	1	1	...	...	...	...	...	...	...
Agram	2	1	...	...	...	1	...	...	...
Temesva	1	1	...	...	...	...	...	...	...
Neusatz	1	...	...	...	...	...	1	...	...
Hermannstadt	2	1	...	...	...	...	...	...	1
Cronstadt	2	1	...	...	...	...	...	...	1
Lemberg	2	1	...	1	...	...	...	...	...
Cracow	1	...	...	1	...	...	...	...	...
Zara	2	...	...	...	...	...	...	1*	...
Totals	59	45	2	2	2	1	1	1	2

* In addition to one in Italian.

In 1856 the leading papers of Vienna,—namely, the *Ost Deutsche Post*, the *Orsterreichische Zeitung*, and the *Wanderer*,—were in a thriving state. The imposition in the autumn of 1857 of a heavy stamp duty on Austrian newspapers, together with an additional 50 per cent. on the tax upon advertisements, coming, too, as they have come, at a time of commercial difficulty, will destroy this prosperity, and will be another blow at the progress of opinion and free aspiration. But it is a step thoroughly Austrian, and will, when the end arrives, be found to have had its due reward.

Prussian newspaper press.

In Prussia the influence of the events of 1848 upon the newspaper press was naturally much greater, and it has been also more enduring, than in most other parts of Germany. There the ground was to a great extent prepared for freer discussion, and the men who undertook it were better fitted for their work. But even here the contrast between the present reality and the past anticipation is not enlivening. There is much activity; little independence. The journals which enjoy the widest circulation are distinguished by literary merit and political servility. The *Berliner Privilegirte Zeitung* had 12,200 subscribers in 1855; the *Berlinischen Nachrichten*, 7600; the notorious *Kreuzzeitung*, the organ of the re-actionists (founded on the 1st July 1848), has 5000; the *Zeit*, 6600; the *National Zeitung*, 5400. Of the provincial press, the *Kölnische Zeitung* is foremost; next to it come the Gazettes of Konigsberg, Aix-la-Chapelle, and Breslau.

Newspapers.

In Sweden the earliest regular newspaper appears to have been the *Ordinarie Post-Tidende*, first published in 1643, and continued until 1680, which was followed by the *Svensk Mercurius* (1675–1683), and the *Relationes Curiosæ* (in Latin, like their titles) which began in 1682, and ceased in 1701. In 1742 a Swedish newspaper in French (*Gazette Française de Stockholm*) was commenced, and was followed, in 1772, by the *Mercure de Suède*. But the press in Sweden had small political influence until so recent a date as 1820, when the *Argus* was established by Johannsen. The strife between "Classicists" and "Romanticists" spread itself in Sweden, as in France, from the field of literature into that of politics. Crusenstolpe's *Fäderneslandet*, and Hjerta's *Aftonbladet*, were long the most conspicuous of the Swedish journals; the former on the side of the royalists, the latter on that of the reformers. Hjerta's paper, in its best day, could boast of a circulation of 5000 copies; but on the accession of King Oscar it ceased to appear as an opposition organ. The official paper is *Post och Inrikes Tidningar*, the original title of which was *Sveriges Statstidning*. Almost every town in the provinces has its paper. The growth of the Swedish press during the present century may be thus epitomized:—

The newspapers of Sweden.

Year.	No. of Papers.	Year.	No. of Papers.	Year.	No. of Papers.
1801	25	1829	62	1841	112
1821	48	1831	80	1850	113

Newspapers of Denmark, and of Norway.

If in Sweden the political influence of the press is a novelty, in Denmark it is a newer thing still. Until 1830 Copenhagen had but two papers, and they filled their columns with mild extracts from foreign journals. Real activity in this direction dates but from the establishment of the Provincial States in 1834. The oldest existing paper is the *Berlingske Tidende*, which dates from 1749, and was at first published in German. It is now a semi-ministerial journal. The *Fädrelandet* belongs to the opposition, and in 1848–9 was in a glow of zeal for Scandinavianism and "Young Denmark." The total number of political journals existing in 1849 was 36. Those belonging to the provinces are of small account. The oldest Norwegian paper is the *Christiania Intelligentssedler*, founded in 1763. Next to this comes the *Adressecontoirs Efterretninger*, published at Bergen. *Den Constitutionelle* is the organ of the government, and has absorbed (for in newspaper affairs incorporation almost always means absorption) an older paper, called *Norske Rigstidende*. The *Morgenblad* is the journal of the popular party, and dates from 1819.

(*Allgemeine Deutsche Real-Encyclopädie, oder Conversations-Lexikon* (Zehnte Auflage, 1855), xv. 474–487, art. "Zeitungen"; *Journal of the Statistical Society of London*, iv. 127–131, art. "Statistics of Newspapers in various Countries," by P. L. Simmonds; *Biographie Universelle*, arts. "Bertuch," "Cotta," "Huber," "Posselt," &c.)

V.—NEWSPAPERS OF HOLLAND AND BELGIUM.

Nieuwe Tydinghen, published at Antwerp in 1605.

In respect of the first publication of a newspaper, Belgium takes rank before France, Germany, and Britain. The *Nieuwe Tydinghen* of Antwerp, published by Abraham Verhoeven, dates from 1605, as appears by the privilege accorded to him for the exclusive retailing of news by the Archdukes Albert and Isabella. But as no copy of any number of this paper anterior to 1619 is now known to exist, the statement must stand open to correction upon a point which is at present doubtful,—the fact, namely, whether or not this "Tydinghe" was *from its origin* a regular periodical. M. de Jonghe possesses portions of it from 1619 to 1630. It seems probable that the *Gazette Extraordinaris Posttydinghen*, published by Wilhem Verdussen between 1637 and 1644, is a continuation of Verhoeven's paper. But be this as it may, that of Verdussen was certainly the foundation of the well-known *Gazette van Antwerpen*, which continued to appear until 1827.

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Early journals of Bruges, and of Brussels.

Bruges had also its *Nieuwe Tydinghen uyt verscheyde gemesten*, published (in black letter) *Te Brugghe, by Nicholaes Breyghel, in de Phlips-Stoc-Straete aen S. Donaes.* When this paper was commenced is uncertain, but various numbers of it exist with dates ranging between 1637 and 1645. In one of these (26th July 1644) a *Brusselsche Gazette* of the 24th of that month is quoted, but for which citation, no Brussels paper is known of earlier date than 1649. When the first number of *Le Courrier véritable des Pays-Bas* made its appearance, the publisher (Jean Mommaert) prefaces the first number by an address to the reader, in which he says:—"I have long endeavoured to meet with somebody who would give employment to my presses in defending truth against the falsehoods which malignity and ignorance *send daily abroad.* I have at length found what I sought, and shall now be able to tell you weekly the most important things that are going on in the world." This paper became afterwards the *Gazette de Bruxelles*, then *Gazette des Pays-Bas;* and, under the last-named title, it continued to appear until 1791. The *Annales Politiques* of Linguet was one of the most remarkable of the political journals of Brussels in the last century. For a time the editor won the favour of the Emperor Joseph II. by praising his reforms, and the government subscribed for 1200 copies of his paper at two louis d'ors each a year; but here, as in almost every other place of residence during his chequered career, Linguet at length incurred fine and imprisonment. His journal was at one time so popular that a printer in Brussels itself regularly and rapidly published a pirated edition of it. When the editor exposed the fraud in very severe terms, the pirate faithfully copied the censure without a word of comment. *Le National* was a famous paper for a short period prior to the revolution of 1830. Soon after its cessation [its presses were destroyed by the populace on the 26th August] the official journal, *Moniteur Belge*, was established—"the ministry deeming it indispensable, to the success of its great political enterprise, that a journal should be created which might expound its views, and act daily upon public opinion;" and, on decree of the regency, it was published accordingly.

Linguet's Annales Politiques.

Dutch newspapers.

The first newspaper published at Ghent, *Gazette van Gend*, appeared in 1667. *Den Vaderlander*, begun in October 1829, is one of the most widely-circulated of the Flemish journals. Holland has always been rich in newspapers, but they have usually had more weight commercially than politically. Those in most esteem are the *Allgemeene Handelsblad* of Amsterdam; the *Harlemsche Courant;* and the *Staats Courant*, and *Journal de la Haye*, both of which are printed at the Hague.

(Warzée, *Essai Historique et Critique sur les Journaux Belges*, Gand, 1845, passim; *Allgem. Deutsche-Real Encyclopädie*, ut supra; Kolb, art. "Linguet" in *Biographie Universelle.*)

VI.—NEWSPAPERS OF ITALY AND OF THE PENINSULA.

Venetian Gazettes.

Of the manuscript gazettes or "notizie scritte" of Venice, little need here be said. They are memorable as indications of the Venetian policy, and also as having probably given us (from the small coin for which they might be read at certain public places) our word "gazette;" but, like their congeners in England and in Germany, were not newspapers. The often-quoted bull of Pope Gregory XIII. was aimed rather at the writers than at the printers of news, and when these narratives or "relations" were at length printed, they were occasional, not periodical. Nor can it, we believe, be fixed with any certainty at what date or in what part of the country an Italian serial newspaper was

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first printed. In recent times Italy has had many admirable scientific and literary magazines, but political journalism has scarcely taken root in that soil. The *Diario di Roma*, the *Gazzetta di Napoli*, and many similar papers published "with approbation" in Lucca, Bologna, Milan, and Florence, have never possessed much influence either for good or evil.

Newspaper press of Sardinia.

In later days, however, Sardinia has formed a notable exception to this state of things. No fewer than 45 purely political papers were published in the Sardinian dominions in 1852, and of these 41 were in Italian and 4 in French. The leading journal was the *Parlamento*, which, in 1855, altered its name to *Piemonte*. The *Opinione* represents the party of progressive reform; the *Armonia* the clerical party. The popular paper, entitled *Gazzetta del Popolo*, had, at the last-named date, about 7000 subscribers. Of the vast crowd of journals of a popular kind, many of them marked by ability, but nearly all of necessity still more remarkable for extravagance, which rushed forth so tumultuously in many parts of Italy in 1847 and 1848, few survived the re-action and the repressive atrocities of 1849.

Spanish journalism.

In Spain no newspaper of any kind existed earlier than the last century. Even within half a century of the present year, its capital contented itself with a single journal, the *Diario de Madrid*. The peninsular war, and the establishment of the Cortes, gave the first impulse towards something which might be called political journalism, but the change from total repression to absolute freedom was too sudden not to be grossly abused. The *Diario de los Cortes*, the *Semanario Patriotico* (published at Cadiz from 1808 to 1811), and the *Aurora Mallarquina* (published at Palma in 1812–13), are the first of the new papers that attained importance. Most of them fell with the Cortes in 1823. In the following year Ferdinand decreed the suppression of all the journals except the *Diario* and the *Gaçeta* of Madrid, the *Gaçeta de Bayona*, and certain provincial papers which dealt exclusively with commercial or scientific subjects. At the close of his reign but three or four papers were published in Madrid. Ten years afterwards there were 40; but their number is far more noticeable than their value. Spanish newspapers have been too often the mere stepping-stones of political adventurers, and not unfrequently the worst of them appear to have served the turn more completely than the best. Gonzales Bravo attained office mainly by the help of a paper of notorious scurrility,—*El Guirigay*. The *Universal* and the *Correo* were successively the tools of José Salamanca. At the end of 1854 the number of political journals published in Madrid was about 40, and the most conspicuous of them were *España* and *El Clamor Publico*. In Portugal the newspaper press is of still less account. The number of newspapers published in Lisbon in 1852 was 7; in Oporto, 5. The *Diario do Governo* is the official organ.

(*Allg. Deutsche Real-Encyclopädie*, ut supra, 456–460; Ford, *Handbook for Spain*, 3d edition, 666, 667; *British Quarterly Review*, vi., 315–332, art. "Newspaper Press of Spain.")

VII.—NEWSPAPERS OF INDIA, AND THE RESTRICTIONS IMPOSED ON THEM.

For a considerable period in the history of the government of India by the Company, the Indian press was very unimportant both in character and influence. It was permitted to shape its course and to gain a position as it could, under the potent checks of the deportation power and the libel law, without any direct censorship. Nor was it found difficult to inflict exemplary punishment on the writers of "offensive paragraphs."

Prior to Lord Wellesley's administration the most considerable newspapers published at Calcutta were *The World, The Bengal Journal, The Hurkaru, The Calcutta Gazette* (the organ of the Bengal government), *The Telegraph, The Calcutta Courier, The Asiatic Mirror*, and *The Indian Gazette*. Mr Duane, the editor of the first-named paper, was sent to Europe in 1794 for "an inflammatory address to the army;" as was Mr Charles Maclean, four years afterwards, for animadverting in *The Telegraph* on the official conduct of a local magistrate.

Newspapers.

Lord Wellesley was the first governor-general who created a censorship (April 1799). The circumstances of the time were critical: the war with Tippoo was at its height. In writing to Sir Alured Clarke, Lord Wellesley thus expressed himself:—"I cannot but suspect the existence of a systematic design of mischief among the editors of several papers, particularly *The Asiatic Mirror*, *The Telegraph*, and *The Post* . . . To-day I find in *The Post* . . . a plain suggestion to Tippoo of the advantages which he might derive by sending his looties into the Carnatic; and in *The Mirror* . . . you will find a dissertation on the causes, nature, and extent, of the conspiracy discovered in Bengal. . . . *I request you will embark the editor of that paper* (whom I understand to be a Mr Bruce, a desperate Jacobin) *for Europe in the first ship which shall sail from Calcutta.*" His lordship then proceeds to establish certain regulations for the future control of the press, and adds that he is determined, on his return to Bengal, to limit "the extravagant number of newspapers now published in Culcutta." Of the new press code, the most important section runs thus:—"1. No paper to be published at all until it shall have been inspected by the Secretary to government, or by some person authorized by him for the purpose." It is honourable to the memory of the noble marquis, that on maturer thought, when the passing excitements of the moment had given place to the judicial analysis of self-examination, and when policy had been tested by time, he indicated his changed views, and his desire that the decree of April 1799 should not be made a model, by striking out all the passages relating to the Calcutta newspapers from the revised *Dispatches*, which he was sending to the press.

Lord Wellesley's exposition of the motives and aims of the censorship of 1799.

According to Mr H. H. Wilson, the later historian of British India, "the duties of the censorship were leniently discharged;" and he inclines to think that "this control, *and the improving tastes and feelings of the age*, gave to the Indian chronicles a new character, and rendered them respectable, *if not very authentic*, vehicles of public information." But the Marquis of Hastings appears to have judged less favourably of their operation. He thought it more important to secure (to use his own words) "the salutary control which public scrutiny exercises over supreme authority, and the cheerfulness and zeal with which all ranks of society co-operate in measures the motives and objects of which they understand, and in which they concur." He therefore, in 1818, abolished the censorship. Whatever the "leniency" of its application may have been, the position of the newspaper press was unmistakeable. We find it significantly marked by Lord Wellesley himself, when he wrote in 1804 to the Danish governor of Serampore, in reply to a complaint against a Bengal journal,—"*The necessary orders* have been communicated to the editors of the newspapers published in Calcutta, for the purpose of preventing the publication of any injurious reflections," &c.

Abolition of the censorship by Lord Hastings in 1818.

The power of transporting obnoxious editors to Europe of course remained. Perhaps the most notorious of all instances of its exertion was that of the editor of *The Calcutta Journal*, the late Mr J. S. Buckingham, which occurred immediately after Lord Hastings' departure from India, and during the government of his temporary successor, Mr John Adam. What Lord Hastings had regarded as salutary Mr Adam stigmatized as highly pernicious. "The governor-general," he wrote, "protests against the assumption of this right of control over the government and

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its officers by a community constituted like the European society of India." The removal of Mr Buckingham was followed closely (14th March 1823) by a new licensing act, far exceeding in stringency that of Lord Wellesley, which had been cancelled five years before; and on the 5th of April 1823, by an elaborate "Regulation for Preventing the Establishment of Printing-Presses without License, and for Restraining, under certain circumstances, the Circulation of Printed Books and Papers." Of this document, it is enough to say, that it appears to have been framed with admirable fidelity on the Star-Chamber precedents of the sixteenth century. The first application of it was to the suppression of *The Calcutta Journal.*

Licensing laws of 1823.

Under the Marquis of Hastings, the germ of a native press had ventured to show itself. Persian and Bengal papers had just started up, when the new laws nipped most of them in the bud. In some cases, however, natives succeeded in obtaining the necessary licenses for the establishment of others. Meanwhile a question grew into importance which had not been provided for,—the right, namely, of the Company's servants to connect themselves with the European press, whether as writers or as proprietors. On this subject Lord (then Sir C.) Metcalfe recorded a remarkable minute in December 1828. At this date the repressive laws of 1823 had been already in practice relaxed. Lord Metcalfe was strongly in favour of increased liberty. He desired that ample power should always be possessed by the local government for "protecting the safety of the state," but thought that "to crush what is in itself capable of great good, from an apprehension that it may possibly, under circumstances as yet unconceived, be converted into an evil, would be a forecast more honoured in the breach than in the observance;" and regretted "that the orders of the Court of Directors have not left employment in the press open to all their servants, except those in high official stations, . . . on the indispensable condition that such employment should not be allowed to interfere with the due discharge of public duties."

Connection of government servants with the press.

State of the Indian press in 1832.

In the course of the elaborate inquiry into the administration of the government of India, which occupied both Houses of Parliament in 1832, prior to the renewal of the Company's charter, the statistics of the Indian press were thus stated:—(1. European.) Three daily newspapers, *The Bengal Hurkaru, The John Bull, The Indian Gazette;* one bi-weekly, *The Government Gazette;* and two weekly, *The Bengal Herald,* and *The Oriental Observer.* (2. Native.) *Janrie Jehan Numa, Summachar Chunduca, Sunbad Tuneer Nassuk, Bunga Doot, Sunbad Coumoody.*[1] At this period every paper was published, under a license, revocable at pleasure, with or without previous inquiry or notice.

The press under Lord W. Bentinck.

But, in the words of Mr Sutherland, "Lord William Bentinck never interfered with the press, and it has been privately understood he never will do so." He was wont to say, according to another good authority, Mr Kaye, "I do not care a straw for the vituperations of the press; . . . but I have learned more from it than from all the other sources of information which have been open to me since I assumed the government of this country." At Madras, on the other hand, it remained under rigid restriction. The papers, said Mr Sullivan in 1832, "are submitted to the chief secretary before publication, and he runs his pen through . . . . whatever may appear to him objectionable." The Madras censorship was removed whilst the parliamentary inquiry of 1832 was still pending. *The Bengal Hurkaru* was, at the date of Lord W. Bentinck's government, the journal of largest circulation, its average issue (daily edition and tri-weekly editions together) being 1500.

One question only, and that but for a brief interval, disturbed Lord William Bentinck's love of free discussion. The too famous "Half-Batta" measure led him to think that a resolute persistence in an unwise policy by the home government against the known convictions of the men actually at the helm in India, and an unfettered press, were two things that could scarcely co-exist. It was on this occasion that Sir Charles Metcalfe recorded his minute of September 1830, the reasoning of which amply justifies the assertion—"I have, for my own part, always advocated the liberty of the press, believing its benefits to outweigh its mischiefs; and I continue of the same opinion."

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This opinion was nobly carried out in the memorable law drafted by Mr (now Lord) Macaulay, and enacted by Sir Charles Metcalfe, as governor-general in 1835. Mr Macaulay's minute (16th April 1835) contained the pertinent question—"It is acknowledged that in reality liberty is, and ought to be, the general rule, and restraint the rare and temporary exception. Why, then, should not the form correspond with the reality? Why should our laws be so framed as to make it appear that the ordinary practice is in the highest degree oppressive, and that freedom can be enjoyed only by occasional connivance?" The law of 1835 totally abrogated the licensing system. It left all men at liberty to express their sentiments on public affairs, under the legal and moral responsibilities of ordinary life. It had the hearty approval of most Indian statesmen in the front rank. But it was as heartily condemned by the Court of Directors at home; and for Sir Charles Metcalfe, it virtually cancelled (as far as the East India Company was concerned) the honourable and eminent services of thirty-seven years.

Lord Metcalfe's law of 1835.

And, after all, the directors discovered that they dared not insist on a return to the system of licenses. The press increased in vigour and influence, and as unquestionably rose in character. There were, as there will always be, discreditable exceptions, in which bad men employed in the light of day energies which, under the old system, would have found their vent in underground channels. But in the main the results have vindicated the policy. Lord Metcalfe's law remained in force until the outbreak of the wretched Sepoy mutiny.

Lord Canning's law of 1857.

The Act No. XV. of 1857 is entitled, "An Act to regulate the establishment of Printing Presses; and to Restrain in certain cases the Circulation of Printed Books and Papers." Like that of 1823, on which it is closely modelled, it absolutely prohibits the keeping or using of printing-presses, types, or other materials for printing, in any part of the territories in the possession and under the government of the East India Company, except with the previous sanction and license of government." It also gives full powers for the seizure and prohibition from circulation of all books and papers, whether printed within the Indian territories or elsewhere.

The results of this licensing act have yet to be learned. It is enacted for one year from its date; and the Minutes of the government at Calcutta expressly deprecate the criticism of its policy, otherwise than as a temporary measure. But the Court of Directors, more cautiously, in the despatch approving it (26th August 1857), take occasion to say,—"We do not think it necessary at present to enter on the general question of the freedom of the press in India."

Whatever may be the eventual verdict of informed English opinion on the government of India by the Company, considered as a whole, there can be nothing premature in the assertion, that in their relations with the press, both the directors at home and the functionaries who have most fully

[1] We give precisely the unusual orthography which appears in the Company's edition of the Reports relating to India. According to Mr Wilson there were in 1846 eight native newspapers printed in Calcutta, besides others at the different presidencies.

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enjoyed their confidence in India, have uniformly distrusted and dreaded free speech and unfettered discussion. But men whose names will long live in the veneration of the natives of India, as well as in the memories of their fellow-countrymen, are found to be on the other side. That they are so, is of good omen for the future.

(*Minutes of Evidence on the Affairs of the East India Company*, February to July 1832, i. 98–101; 166–180 (Company's edition); *Report of the Select Committee of House of Commons on the Affairs*, &c., 16th August 1832, 31, 32 (ibid.); *Report from Select Committee on the Suppression of the Calcutta Journal*, 4th August 1834; *Minutes*, 85–168; *Appendix*, passim; *Second Report from Select Committee on Indian Territories*, 12th May 1853, 64–68; *Further Papers on the Mutinies in the East Indies*, 1857, No. 5, 89–96; *Returns relating to the Restriction of the Liberty of the Press in India*, 24th August 1857, passim; *Selections from the Papers of Lord Metcalfe*, 1855, 311 seq.; *The Oriental Herald*, 1824, i., 6–77, 123–142, 197–224; *Letters to the Marquis of Hastings on the Indian Press*, 1824, 61, &c.; *Memoirs and Correspondence of the Marquess Wellesley*, i. 281, ii. 128, seq.; Wilson's *History of British India, from* 1805 *to* 1835, 1848, iii. 581–585.)

Here our slight survey of a wide subject must needs find pause. To say that the newspaper press, with all its ability and influence, is as yet but at the threshold of its career, is neither presumptuous nor hazardous. In Britain, as well as in America, the journals that unite the highest order of talents with a manifestly conscientious sense of responsibility for the use of them, do but put into stronger light the defects of their opposites. We as little believe that the newspaper, at its best, will ever supersede books and pulpits, as we have faith in the much-bruited but very silly assertion, that "a number of *The Times* contains more instruction than all Thucydides." Until the journalists and the readers of a country are alike imbued with the spirit of (at least) their national classics, neither the full powers nor the highest functions of journalism will be elicited. But when a public thus intellectually nurtured shall be daily addressed by a press plainly under the guidance of religious principle, then unquestionably the power of instilling the same thought, at the same moment, into thousands of minds will prove the mightiest of all the secular agents of civilization,—the most effective of all curbs on misgovernment, whether arising from the errors of rulers or the temporary excitements of popular majorities. (E. E.)

Newton, Sir Isaac.

NEWTON, Sir Isaac, a distinguished mathematician and natural philosopher, was born at the manor house of Woolsthorpe, about half a mile to the west of Colsterworth, in Lincolnshire, and some six miles to the south of Grantham. His birth, which was premature, took place on the 25th of December, O. S. 1642. His father, Mr Isaac Newton, was proprietor of Woolsthorpe, worth about L.30 per annum, and farmed it with his own hands. His mother was Harriet Ayscough, the daughter of Mr James Ayscough, of Market-Overton, in Rutlandshire. They had been married only a few months when Mr Newton died, leaving his wife in a state of pregnancy. The posthumous child was so small that "they might have put him into a quart mug," and no expectation was entertained of his continuing to live. "Providence, however," as his biographer observes, "had otherwise decreed; and that frail tenement, which seemed scarcely able to imprison its immortal mind, was destined to enjoy a vigorous maturity, and to survive even the average term of human existence." Mrs Newton possessed a small property in Leicestershire, about three miles from Woolsthorpe, which raised her annual income to about L.80.

In consequence of the marriage of Mrs Newton to the Rev. Mr Smith of North Witham, she left her son Isaac under the charge of her mother. He received his early education at two day schools at Skillington and Stoke; and in his twelfth year he went to the public school at Grantham, taught by Mr Stokes, and was boarded at the house of Mr Clark, an apothecary. Here his attention was less occupied with his studies than with the mechanical amusements, in which he spent all his leisure hours. Models of wind-mills, water-clocks, and self-moving carriages, were executed by him in succession; and he contrived to amuse his schoolfellows with paper kites and paper lanthorns, which he raised to great heights in the air.

From the play-things of his childhood, Newton made a rapid transition to higher amusements. The daily movements of the sun were traced upon the walls and roofs of the buildings at Woolsthorpe. By means of pins and lines he indicated the hours and half hours of his rude dials; and though he was now employed in tending the cattle, and going to the market at Grantham, yet he was often found studying mathematics under a hedge, or gleaning fragments of science from old books in Mr Clark's garret at Grantham. This inattention to the duties of the farm increased with his years, and his mother came to the resolution of giving him an academical education. After the preparation of a few months at Grantham school he was sent to Cambridge, where he was admitted a subsizer of Trinity College on the 5th of June 1661, a bachelor of arts in 1665, a junior fellow in 1667, and master of arts in 1668. Young Newton's attention was first turned to the study of mathematics by a a passion for judicial astrology. He considered the propositions in Euclid as self-evident truths; and in the geometry of Descartes, the *Miscellanies* of Schooten, the *Clavis* of Oughtred, and the *Arithmetic of Infinites* of Wallis, he acquired his first knowledge of the mathematics. Kepler's *Optics* and Saunderson's *Logic* were amongst the books which he carefully studied, and upon which he wrote comments; and so rapid was his progress in knowledge, that he was considered as being more deeply versed in several branches than his own tutor. In the year 1666 he purchased a prism for the purpose of studying Descartes' Theory of Colours; and early in 1668 three additional prisms, which were no doubt those used by him in his experiments. He had in 1666 applied himself to the grinding of "optic glasses of other figures than spherical;" and finding that there were other causes than the imperfect converging of rays to a focus which rendered refracting telescopes imperfect, he was led to inquire into the cause of the colours produced by lenses and prisms, and to make those splendid discoveries respecting the different refrangibility of the rays of light, the history and nature of which will be found in the article Optics.

Having despaired of improving the refracting telescope, Newton directed his attention to the reflecting one. At this time Gregory's *Optica Promota*, published in 1663, fell into his hands; and, in considering the construction of the Gregorian telescope there described, "he found the disadvantages of them so great," "that he altered the design of it, and placed the eye-glass at the side of the tube rather than at the middle." On this altered principle he executed a reflecting telescope with his own hands in the year 1668. In 1671 he finished a better one, which was shown to the king, and presented to the Royal Society, in whose custody it still remains.

Although Newton delivered a course of lectures on optics in Cambridge in 1669, 1670, and 1671, containing an account of his discoveries respecting the different refrangibility of the rays of light, yet the Royal Society was not acquainted with them till 1672. On the 23d of December 1671 he was proposed as a member of that body by Dr Seth Ward, bishop of Sarum, and he was elected on the

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11th of January 1672. On the 6th of February he communicated to Mr Oldenburg his discoveries respecting light, which he regarded as "the oddest, if not the most considerable, detection which had hitherto been made in the operations of nature."

No sooner was it communicated to the world that *white* light consists of seven different colours, having different degrees of refrangibility, than a crowd of obscure individuals assailed, not only his conclusions, but the accuracy of the experiments from which they had been derived. Dr Hooke and Huygens attacked them on different grounds; but Newton, in a letter to Oldenburg, dated the 11th of June 1672, silenced the arguments of his opponents, and established his general doctrine upon an impregnable basis.

The colours of thin plates, first observed by Boyle, and studied by Hooke, had occupied the special attention of Newton. The results of his inquiries were laid before the Royal Society on the 7th of December 1675, and about twelve years afterwards the theory of *fits* was completed, and applied to the explanation of the permanent colours of natural bodies. These researches, however, including his experiments on the inflexion of light, which he gives only as an imperfect fragment, were not published till 1704, when his treatise on Optics appeared. (See the article Optics).

The first idea of gravity as the cause of the celestial motions occurred to Newton in the year 1666, when sitting alone in the garden of Woolsthorpe. Conjecturing that it might extend as far as the moon, he was led to confirm the conjecture by calculation, and thus to establish the doctrine of universal gravitation, "that every particle of matter is attracted by, or gravitates to, every other particle of matter, with a force inversely proportional to the square of the distance." This great discovery, and its application to the movements of the planetary system, as well as to that of the comets, was published in 1686, in his *Philosophiæ Naturalis Principia Mathematica*, a work which, to use the words of Newton's biographer, "is memorable, not only in the annals of one science or one country, but will form an epoch in the history of the world, and will ever be regarded as the brightest page in the records of human reason." This remarkable production was speedily circulated over Europe; and although the discoveries which it contained were for a while opposed by national as well as personal jealousies, yet the Newtonian philosophy made rapid progress, and finally supplanted the rival systems of Aristotle and Descartes.

As early as the year 1666 Newton had discovered the binomial theorem and the method of fluxions; and although he had not communicated this discovery to any of his friends, yet he had clearly described the principle, and exhibited the application of his method, in his *Analysis per Equationes numero Terminorum infinitas*, a work which he had communicated to Dr Barrow in June 1669, and which was not published till 1701, nearly half a century after it was written. Our readers are well aware that the discovery of fluxions was claimed by Leibnitz, and that the controversy which sprung out of this claim is scarcely yet at an end.[1]

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From the year 1669, when Newton was appointed to succeed Dr Barrow as Lucasian professor of mathematics at Cambridge, till 1688, he led a secluded life within the walls of his college; but events now occurred which drew him from retirement, and placed him conspicuously on the stage of public life. James II., desirous of re-establishing the Catholic faith as the national religion, had begun to assail the privileges of his Protestant subjects. He ordered Father Francis, an ignorant Benedictine monk, to be received at Cambridge as a master of arts, and the oaths of allegiance and supremacy to be dispensed with. The university resisted this illegal mandate, and chose nine delegates to defend their independence. Having joined in resisting the wishes of the court, Newton was chosen one of the delegates; and such was their firmness, and the argumentative weight of their representations, that the king was led to abandon his design. Newton's popularity was extended by the success of the delegates, and he was elected member for the university in 1688, along with Sir Robert Sawyer, having beaten Mr Finch by only five votes. Newton sat in the convention parliament from January 1689 till its dissolution in February 1690.

In the discharge of his parliamentary duties, he no doubt experienced the unsuitableness of his income to his new position. The limited means of his relations, and his own generous disposition, had exhausted his scanty resources, and he and his friends naturally looked to some patronage on the part of the government which might enable him to pursue his scientific researches, unembarrassed by those physical wants which have ever been the scourge of genius, and especially of that variety of it which is called forth by patient and continuous inquiry. There is ample evidence that unsuccessful applications had been made for this purpose; and the vexation and disappointment which this ingratitude produced, combined with other causes, seem to have thrown Newton into a state of nervous irritability, which threatened to paralyze even his mighty intellect. It is difficult to trace with distinctness the succession of causes which at this time contributed to disturb his serenity; but it has been said that, about the end of 1692, or early in 1693, his chemical laboratory had been burned, and a number of manuscripts destroyed; and on another occasion, several valuable manuscripts were consumed by a candle which he had left burning whilst he went to chapel. These losses seem to have affected him deeply, and "he was so troubled thereat, that every one thought he would have run mad, and he was not himself for months after." Another account of these events, communicated by one Colin or Collins to Huygens,[2] represents Newton as

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[1] A full account of this controversy will be found in the article Fluxions, and in Preliminary Dissertation IV., part ii., § 1. Many curious facts and documents recently brought to light will be found in Sir David Brewster's *Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton*, 1855, chaps. xiv. and xv.

[2] The following extract from the manuscript of Huygens was first published in Biot's *Life of Newton*:—"On the 29th of May 1694, M. Colin (*Collins* or *Colm*), a Scotsman, informed me that, eighteen months ago, the illustrious geometer Isaac Newton had become insane, either in consequence of his too intense application to his studies, or from excessive grief at having lost by fire his chemical laboratory, and several manuscripts. When he came to the Archbishop of Cambridge (Canterbury), he made some observations which indicated an alienation of mind. He was immediately taken care of by his friends, who confined him to his home, and applied remedies, by means of which he had now so far recovered his health that he began to understand the *Principia*." The M. Colin here mentioned was Mr Collins, the son of John Collins, the early friend of Newton. (See *Memoirs of Newton*, &c., 1855, vol. ii., p. 131, note.)

The following extract from a manuscript journal kept by Mr Abraham de la Pryme, an ancestor of Professor Pryme, when a student at Cambridge, throws much light on this part of Newton's life:—"1692, Feb. 3. What I heard to-day I must relate. There is one Mr Newton (whom I have very often seen), fellow of Trinity College, that is mightily famous for his learning, being a most excellent mathematician, philosopher, divine, &c. He has been fellow of the Royal Society these many years; and amongst many other very learned books and tracts, he has written one upon the mathematical principles of philosophy, which has got him a mighty name, he having received, especially from Scotland, abundance of congratulatory letters for the same. But of all the books which he ever wrote, there was one of *Colours and Light*, established upon thousands of experiments, which he had been twenty years of making, and which had cost him many hundreds of pounds. This book, which he valued so much, and which was so much talked of, had the ill luck to perish,

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having actually become insane, and unable to understand his own writings; and, relying upon the accuracy of this statement, M. Biot and other French philosophers considered his insanity as the reason why Newton had ceased to make scientific discoveries. They even went so far as to ascribe his study of theology to this enfeebled state of mind, and thus to deprive our faith of that support which it derived from having been illustrated and defended by so great an expositor and champion.

That the mind of Newton was sound and active during the period when it is said to have been seriously disturbed, has been proved by many undoubted facts. In this interval he composed his four celebrated letters to Dr Bentley on the existence of a Deity; letters which evince a power of thought, and a serenity of mind, incompatible even with the slightest obscuration of his faculties. The *first* of these letters was written on the 10th of December 1692; the *second* on the 17th of January 1692–3; the *third* on the 11th of February, and the *fourth* on the 25th of February 1693–4. These letters were written in answer to some queries sent to him by Dr Bentley. After Dr Bentley had received the *third* letter, he sent to Sir Isaac an abstract of his first unpublished sermon, requesting him "to acquaint him with what he found in it not conformable to truth and his hypothesis;"[1] and it was to this letter that the *fourth* was a reply. In 1692 we find him also engaged in mathematical researches on the quadrature of curves, and in observations on halos; and in November and December 1693 he was occupied in discussing mathematical questions with his correspondents. On the 1st of September 1694 Newton visited Flamsteed at Greenwich, and he was at that time occupied with the difficult and profound subject of the lunar theory, and with his fine theory of astronomical refractions.

That Newton's health was affected from the middle of 1692 to the middle of 1693, is quite certain; and that his nervous system was shaken by loss of sleep and appetite, is mentioned by himself. Exaggerated rumours had reached his friends in London, and Mr Pepys was led to inquire if these rumours of a discomposure of his mind had any foundation. Mr J. Millington, who was tutor of Magdalene College, returned the following answer:—"I was, I must confess, very much surprised at the inquiry you were pleased to make by your nephew about the message that Mr Newton made the ground of his letter to you, for I was very sure I never either received from you or delivered to him any such; and, therefore, I went immediately to wait upon him, with a design to discourse with him about the matter; but he was out of town, and since I have not seen him, till, upon the 28th, I met him at Huntingdon, where, upon his own accord, and before I had time to ask him any question, he told me that he had writt to you a very odd letter, at which he was much concerned; added, that it was in a distemper that much seized his head, and that kept him awake for about five nights together, which, upon occasion, he desired I would represent to you, and beg your pardon, he being very much ashamed he should be so rude to a person for whom he hath so great an honour. He is now very well, and though I fear he is under some small degree of melancholy, yet I think there is no reason to suspect it hath at all touched his understanding, and I hope never will; and so I am sure all ought to wish that love learning, or the honour of our nation, *which it is a sign how much it is looked after*, WHEN SUCH A PERSON AS MR NEWTON LYES NEGLECTED BY THOSE IN POWER."

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In the beginning of the year 1692, Charles Montague, Lord Monmouth, and Mr Locke, were exerting themselves to obtain some appointment for Newton. In his letters to Locke, Newton himself refers, with a considerable degree of feeling, to these exertions. He conceived that Charles Montague, under the influence of some old grudge, had been false to him, and that there had been a design to sell him an office; and it is to the failure of these attempts that Mr Millington alludes with such just severity in the letter which we have quoted.

Newton was now in the fifty-third year of his age; and whilst those of his own standing at the university had been appointed to high stations in the church, or to lucrative offices in the state, he still remained without any mark of national gratitude. His fellow-labourers in science in every part of Europe were enjoying the favour and protection of their respective sovereigns, who had even invited foreign philosophers to their capitals to enjoy the liberality which they had extended to their own. Foreigners viewed with astonishment the treatment of Newton by his own sovereign, and in 1698 the French king had the nobleness of mind to offer him, through Cassini, a liberal pension.

But this blot upon the English name was at last removed by Charles Montague when, in the year 1694, he was appointed chancellor of the exchequer. He had previously consulted Mr Newton upon the subject of the recoinage; and when Mr Overton, the warden of the mint, was made a commissioner of customs, he served both his friend and his country by appointing Newton to that important office. "I am very glad," says he, "that *at last* I can give you a good proof of my friendship, and the esteem the king has of your merits. Mr Overton, the warden of the mint, is made one of the commissioners of the customs, and the king has promised me to make Mr Newton warden of the mint. The office is the most proper for you. 'Tis the chief office in the mint; 'tis worth five or six hundred pounds per annum, and has not too much business to require more attendance than you can spare."

The chemical and mathematical knowledge of Newton proved of great use in carrying on the recoinage, which was completed in about two years; and such was the zeal and devotion with which Newton discharged the laborious duties of this office, that he was appointed, in 1697, to the mastership of the mint, which was worth between twelve and fifteen hundred pounds per annum. In this situation he drew up a table of assays of foreign coins, and composed an official report on the coinage. Having retained his professorship at Cambridge whilst he was warden, he now appointed Mr Whiston as his deputy, with all the emoluments of the chair.

In 1660 Newton was elected a Foreign Associate of the Royal Academy of Sciences at Paris, along with Leibnitz and the two Bernoullis. In 1701 he was elected one of the members of Parliament for the University of Cambridge. In 1703 he was raised to the presidency of the Royal Society of London, to which he was annually re-elected during the remaining twenty-five years of his life.

When Queen Anne and the court visited Cambridge on the 16th of April 1705, she conferred the honour of knighthood on Mr Newton.

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and be utterly lost, just when the learned author was almost at putting a conclusion to the same, after this manner. In a winter's morning, leaving it among his other papers on his study table, whilst he went to chapel, the candle, which he unfortunately left burning there too, catched hold by some means of other papers, and they fired the aforesaid book and utterly consumed it, and several other valuable writings; and, which is most wonderful, did no further mischief. But when Mr Newton came from chapel, and had seen what was done, every one thought he would have run mad; he was so troubled thereat, that he was not himself for a month after." (Brewster's *Life of Newton*, 1831, p. 228.)

[1] The interesting letter containing this request has been published for the first time in the *Memoirs of Newton*, &c., 1855, vol. ii., App. x., p. 463.

Newton, Sir Isaac.

On the dissolution of Parliament in 1705, Sir Isaac was again a candidate for the representation of the university; but he was beaten by a great majority. He was supported by all the resident members; but being a Whig in politics, and the cry of the church in danger having been raised on that occasion, he became the victim of the ignorance and fanaticism of the non-resident constituency.

The first edition of the *Principia* having been sold off, Dr Bentley and his other friends had, for a considerable time, been urging Sir Isaac to prepare a new edition. The duties of the mint would not permit him to devote much time to such a task; but he willingly complied with the request of his friends, when Mr Roger Cotes, Plumian professor of astronomy at Cambridge, undertook to superintend its publication. Newton promised to send his own revised copy to Mr Cotes in July 1709; but delays took place, and the work was not completed till the spring of 1713. Nearly three hundred letters—passed between Sir Isaac and Cotes, and in which the various alterations and additions are discussed—have been preserved in the library of Trinity College, Cambridge, and published by Mr Edleston in 1850.

When George I. succeeded to the throne of Great Britain, Sir Isaac became an object of interest at court. The Princess of Wales, afterwards queen-consort to George II., took great pleasure in conversing with him, and in corresponding with Leibnitz. Having one day mentioned to her Royal Highness a new system of chronology which he had composed while resident at Cambridge, she requested Sir Isaac, through the Abbé Conti, to give her a copy of it. He accordingly drew up an abstract of it from the loose papers to which it had been committed, and sent it to the princess for her private use alone. He afterwards allowed a copy to be given to the Abbé Conti, on the condition of its not being communicated to any person whatever. The abbé, however, forgetting his obligation, communicated it to M. Fréret, a learned antiquary in Paris, who translated it, and endeavoured to refute it. It was printed early in 1725, under the title of *Abrégé de Chronologie de M. le Chevalier Newton, fait par lui-même, et traduit sur le Manuscrit Anglais.* Upon receiving a copy of this work, Sir Isaac Newton printed, in the *Philosophical Transactions* for 1725, a paper entitled, "Remarks on the observations made on a Chronological Index of Sir Isaac Newton, translated into French by the observator, and published at Paris." In these remarks Sir Isaac charges the abbé with a breach of promise, and gave a triumphant answer to the objections which Fréret had urged against his system. Father Souciet entered the field in defence of Fréret; and in consequence of this controversy, Sir Isaac was induced to prepare his larger work, which was published in 1728, after his death, and entitled the *Chronology of Ancient Kingdoms amended; to which is prefixed a short Chronicle from the First Memory of Kings in Europe to the conquest of Persia by Alexander the Great.*

There is no part of Sir Isaac Newton's biography more remarkable than that which relates to his theological studies. From a very early period of his life Newton had seriously embarked in the study of theology. Previously to 1692 he was known by the appellation of an excellent divine, and it is well known that he had begun to study the subject of the prophecies before 1690; whereas, in order to show that his theological writings were the productions of his dotage, and subject to his supposed mental alienation, M. Biot has fixed their date between 1712 and 1719, between the seventieth and the seventy-seventh year of his age.

One of the most remarkable of Sir Isaac's theological productions is his *Historical Account of Two Notable Corruptions of the Scripture*, in a letter to a friend. This friend was Mr Locke, who received the letter in November 1690. Sir Isaac seems to have been then anxious for its publication; but as the effect of his argument was to deprive the Trinitarians of two passages in favour of the Trinity, he became alarmed at the probable consequences of such a step. He therefore requested Locke, who was then going to Holland, to get it translated into French, and published on the Continent. Being prevented from going to Holland, Locke copied the manuscript, and sent it, without Newton's name, to M. le Clerc, who received it before the 11th of April 1691. On the 20th of January 1692, Le Clerc announced to Locke his intention to publish the pamphlet in Latin; and upon intimating this to Sir Isaac, he entreated him "to stop the translation and impression as soon as he could, for he designed to suppress them." This was according done; but Le Clerc sent the manuscript to the library of the Remonstrants, and it was afterwards published at London in 1754, under the title of *Two Letters from Sir Isaac Newton to M. le Clerc.* This edition is imperfect, and in many places erroneous. Dr Horsley therefore published a genuine one, which is in the form of a single letter to a friend, and was taken from a manuscript in Sir Isaac's own hand, in the possession of the Reverend Dr Ekins, dean of Carlisle.[1]

Newton, Sir Isaac.

Sir Isaac Newton left behind him in manuscript a work entitled *Observations on the Prophecies of Daniel and the Apocalypse of St John*, which was published in London in 1733, in one volume 4to; another work entitled *Lexicon Propheticum*, with a dissertation on the sacred cubit of the Jews, which were printed in 1737; and Four Letters addressed to Dr Bentley, containing some arguments in proof of a Deity, which were published by Mr Cumberland, the nephew of Dr Bentley, in 1756.[2] Sir Isaac also left a Church History complete; a History of the Creation; Paradoxical Questions regarding Athanasius, and many divinity tracts.

Sir Isaac Newton devoted much of his time to the study of chemistry; but the greater number of his experiments still remain in manuscript. His *Tabula Quantitatum et Graduum Caloris* contains a comparative scale of temperature from that of melting ice to that of a small kitchen coal fire. He wrote also another chemical paper, *De Natura Acidorum*, which has been published by Dr Horsley. Sir Isaac spent much time in the study of the works of the Alchemists. He had diligently studied the works of Jacob Behmen, and there were found amongst Sir Isaac's manuscripts copious abstracts from them in his own handwriting. In the earlier part of his life he and his relation Dr Newton of Grantham had put up furnaces, and had wrought for several months in quest of the philosopher's tincture. These views are rendered more probable by the fact, that among the manuscripts in the possession of the Earl of Portsmouth, there are many sheets, in Sir Isaac's hand, of Flamsteed's Explication of Hieroglyphic Figures, and in another hand many sheets of William Yworth's *Processus Mysterii Magni Philosophicus.*

Amongst the inventions of Sir Isaac Newton we must enumerate his reflecting telescope, his reflecting microscope, a sextant similar to Hadley's, and his prismatic reflector, with plane and convex surfaces. We owe also to him some very interesting views on the decussation of the optic nerves, which were first published in Harris's *Optics;* a hypothesis respecting ether as the cause of light and gravity; and some experiments upon the excitation of electricity on glass.[3]

The sale of the second edition of the *Principia* having been rapid, a third edition was called for in 1722. Roger

[1] See Brewster's *Life of Newton*, 1831, p. 276.
[2] The original letters are preserved in the library of Trinity College, Cambridge.
[3] *Newtoni Opera*, by Horsley, vol. iv., p. 375.

Newton, Sir Isaac.

Cotes had died in the prime of life, and therefore Newton engaged Dr Pemberton to superintend the new edition, which was published in 1726, with numerous alterations.[1]

During the last twenty years of Sir Isaac's life, his beautiful and accomplished niece, Miss Catherine Barton, had managed his domestic concerns. She was the daughter of Mr Robert Barton of Brigstock, and of Hannah Smith, Newton's half sister. She had been a great favourite of Charles Montague, Earl of Halifax, who, at his death in 1715, bequeathed to her a very large portion of his fortune. This lady, who had been educated at Sir Isaac's expense, married Mr Conduit, and continued to reside with her husband in Sir Isaac's house until the time of his death. Although the liberality of Lord Halifax to Mrs Barton surprised her contemporaries, yet she was regarded by all who knew her as a woman of strict honour and virtue. As the niece of Newton, and the wife of Mr Conduit, his successor in the mint, she moved in the highest circles; and during the century which has elapsed since her death, it has never even been supposed that her connection with Halifax was impure. Professor De Morgan, however, has recently attempted to show that she must either have been the wife or the mistress of that nobleman; and as there is not the slightest proof of a marriage, we are forced by this groundless hypothesis to take the most painful view of her character. Regarding this opinion as derogatory to the character of Newton, his biographer has shown, in the most satisfactory manner, that there is no foundation whatever for the opinion that Mrs Barton was either the wife or the mistress of Halifax, and has restored her to her high position as the niece of Newton, and the female head of the noble house of Portsmouth.

In the year 1722, when Sir Isaac was eighty years old, he had been seized with an incontinence of urine, which was ascribed to stone. By great attention to diet and regimen he succeeded in keeping down this dreadful malady; but in August 1724 he passed a small stone, and for some months enjoyed a tolerable degree of health. In January 1725 he was seized with a violent cough and inflammation of the lungs, which induced him to reside at Kensington; and in the February of the same year he had a fit of gout both in his feet and hands, which produced a decided improvement in his general health. His duties at the mint were discharged by Mr Conduit, and he therefore seldom went from home. Feeling himself well, he went to London on the 28th of February 1728, to preside at a meeting of the Royal Society; but the fatigue which attended this duty brought on a violent return of his former complaint, and he returned to Kensington on the 4th of March, when Dr Mead and Dr Chesselden pronounced his disease to be stone. He endured the sufferings of this complaint with wonderful patience and meekness. He seemed a little better on the 15th of March, and on the 18th he read the newspapers and conversed with Dr Mead; but at six o'clock in the evening he became insensible, and continued in that state till Monday the 20th of March, when he expired without pain between one and two o'clock in the morning, in the eighty-fifth year of his age. His body was removed to London, and on Tuesday the 28th of March it lay in state in the Jerusalem Chamber, and was thence conveyed to Westminster Abbey, where it was buried near the entrance into the choir, on the left hand. The pall was supported by the Lord Chancellor, the Dukes of Roxburghe and Montrose, and the Earls of Pembroke, Sussex, and Macclesfield, who were fellows of the Royal Society, the Hon. Michael Newton, K.B., was chief mourner. The Bishop of Rochester performed the funeral service. The relations who inherited his personal estate devoted L.500 to the erection of a monument to his memory. It was finished in 1731, and was erected in the centre of the abbey. The following is the epitaph inscribed upon it:— Newton, Sir Isaac.

Hic situs est
Isaacus Newton, Eques auratus,
Qui animi vi prope divina
Planetarum motus, figuras,
Cometarum semitas, Oceanique Æstus
Sua Mathesi facem præferente
Primus demonstravit;
Radiorum Lucis dissimilitudines
Colorumque inde nascentium proprietates
Quas nemo antea vel suspicatus erat, pervestigavit;
Naturæ, antiquitatis, S. Scripturæ
Sedulus, sagax, fidus interpres;
Dei opt. max. majestatem philosophia asseruit;
Evangelii simplicitatem moribus expressit.
Sibi gratulentur mortales, tale tantumque extitisse,
HUMANI GENERIS DECUS
Natus XXV. Decemb. MDCXLII; Obiit XX. Mar.
MDCCXXVII.

In the beginning of the year 1731, a medal was struck at the Tower in honour of Sir Isaac Newton, bearing the motto *Felix cognoscere causas;* and on the 4th of February 1755 a fine full-length statue of him by Roubillac, executed in white marble, was erected in the antichapel of Trinity College, Cambridge, at the expense of Dr Robert Smith, the author of the *Complete System of Optics.* The pedestal bears the inscription from Lucretius,—

Qui genus humanum ingenio superavit;

a eulogium which may be questioned even by those who are the greatest admirers of Newton's genius.

The personal estate of Sir Isaac Newton amounted to about L.32,000. It was divided amongst his four nephews and four nieces of the half blood, the grandchildren of his mother by the Rev. Mr Smith. The family estates of Woolsthorpe and Sustern were bequeathed to John Newton, whose great-grandfather was Sir Isaac's uncle, by whom they were sold in 1732 to Mr Edmund Turnor of Stoke Rocheford. Sir Isaac bequeathed his estate at Kensington to Catherine, the only daughter of Mr Conduit, who afterwards married Mr Wallop, the eldest son of Lord Lymington, and subsequently Earl of Portsmouth. Sir Isaac was succeeded as warden and master of the mint by his nephew, Mr Conduit, who died in 1737.

In his social character Sir Isaac Newton was modest, candid, and affable, accommodating himself to every class of society in which he moved. His humility was that of a philosopher who had experienced both the strength and the weakness of the human mind, and of a Christian who was deeply impressed with the unsatisfying nature of all earthly greatness. "I do not know," said he, a short time before his death, "what I may appear to the world; but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me." His religious and moral character were equally admirable. He was deeply versed in the knowledge of the Scriptures, and was not equalled in point of theological learning by any of the divines of his age. He was a great friend of religious toleration, and never scrupled to express his abhorrence of even the mildest species of religious persecution.

Sir Isaac Newton was remarkable for his liberality upon all occasions. His charity was boundless; and he was in the habit of remarking, that those who gave away nothing till they died never gave at all. He wrote to the Provost of Edinburgh in 1724, offering L.20 annually to Mr Mac-

[1] Pemberton's letters to Newton are among the Portsmouth papers. See Brewster's *Memoirs*, &c., 1855, vol. ii., p. 380.

laurin, provided he became assistant to Mr James Gregory, professor of mathematics in the university. In 1719 he gave fifty guineas to the Rev. Mr Pound, who made some astronomical observations for his use; and in 1720 he gave him the like sum. He likewise bestowed large donations on the Ayscoughs, his relations.

In his personal appearance Sir Isaac was not above the middle size. He had "a comely and gracious aspect, and a very lively and piercing eye." He was short-sighted, but never wore spectacles, nor lost more than one tooth in his life. Bishop Atterbury asserts, in opposition to this, that the lively and piercing eye did not belong to Sir Isaac during the last twenty years of his life. "Indeed," says he, "in the whole air of his face and make there was nothing of that penetrating sagacity which appears in his compositions. He had something rather languid in his look and manner, which did not raise any good expectation in those who did not know him."

There is some reason to believe that Sir Isaac Newton was of Scottish descent, although in the pedigree which he gave into the Herald's Office he stated that *he had reason to believe* that he was descended from the Newtons of Westby. There is, however, ample evidence of the fact that Newton mentioned to David Gregory that it was a tradition in his family that his grandfather was a gentleman in East Lothian; and it has been placed beyond a doubt, that Newton himself wrote to Scotland to ascertain if any descendants of the family remained.[1]

The manor-house of Woolsthorpe, as well as every other memorial of Sir Isaac, has been preserved with religious care. Mr Edmund Turnor of Stoke Rocheford put up in 1798 a white marble tablet in the room where Sir Isaac was born, recording his birth and death, and bearing the celebrated lines of Pope:—

> "Nature and Nature's laws lay hid in Night;
> God said, 'Let Newton be,' and all was light."

The house still contains on its walls the two dials made by Newton himself, but without the styles. His second telescope is preserved in the library of the Royal Society; and his globe, universal ring dial, quadrant, compass, and a reflecting telescope said to have belonged to him, in the library of Trinity College, Cambridge.

The manuscripts, correspondence, and other papers of Sir Isaac Newton, have been preserved in different collections. But the most important collection is the family one in the possession of the Earl of Portsmouth. They are deposited at Hurtsbourne Park, his lordship's seat in Hampshire, and were examined in 1837 by the late H. A. Fellowes, Esq., the accomplished nephew of Lord Portsmouth, and by Sir David Brewster, who has been permitted to make use of them in composing *Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton.* In this examination much new and valuable information has been discovered relative to the early life of Sir Isaac, which had been collected by his nephew-in-law Mr Conduit, for the purpose of writing a life of him, which he was prevented from executing by his death in the year 1737.[2] Many letters and papers of Newton are in the possession of the Earl of Macclesfield at Shirburn. They were found amongst the papers of William Jones, the friend of Sir Isaac, and the father of Sir William Jones. These papers were put into the hands of the late Professor Rigaud of Oxford, and were published in 1841, by his son, in two volumes.

About thirty-four of Newton's letters to Flamsteed are deposited in the library of Corpus Christi College, Oxford; but a large portion of the correspondence between Newton and Flamsteed was found a few years since by Mr Baily in the possession of Mr Giles, a private gentleman in London, and in the Royal Observatory at Greenwich, along with various important documents intimately connected with the scientific history of that period. As the papers found in the observatory had been purchased by the Board of Longitude in 1771, the Lords Commissioners of the Admiralty, on the recommendation of the Board of Visitors of the Royal Observatory, agreed to print them. They have been accordingly printed in a large 4to volume, under the superintendence of Mr Baily.[3]

Doubts have been entertained by some, and openly expressed by others, on the propriety of publishing all the papers contained in this collection. Several of the letters of Flamsteed, and various parts of his autobiographical memoir, contain bitter and maligant attacks upon the character and conduct of Sir Isaac Newton, which, if they had been published during his life, or not long after it, might have been refuted on the authority of documentary and other evidence. Fortunately for the memory of Sir Isaac Newton, his generous and noble character, his meek and gentle disposition, and his Christian forbearance and patience, form a secure shield against the reckless and wanton charges of his irritable and violent assailant. If reflections have been cast on the character of Newton by the animadversions of Flamsteed, the conduct of the latter has been exposed to a scrutiny which it may not be able to sustain; and the friends of Newton have been reluctantly compelled to collect the opinions which contemporary writers had expressed of Flamsteed, in order to enable the public to form a just estimate of the testimony which he has borne against his fellow-labourer in science.

Those who wish to know more of the differences between Newton and Flamsteed, may consult the volume above mentioned, which is entitled "*An Account of the Rev. John Flamsteed*, the first Astronomer Royal, compiled from his own manuscripts, and other authentic documents never before published; to which is added, his British Catalogue of Stars, corrected and enlarged, printed by order of the Lords Commissioners of the Admiralty, London, 1835." Mr Baily, at his own expense, published, in January 1837, a supplement to this work, which he distributed amongst those persons and institutions only to whom the original work was presented." Much light has been recently thrown upon this controversy by the letters of Flamsteed to Newton, and other documents, which Newton had carefully preserved, and which were found among the Portsmouth papers by Sir David Brewster. These documents have enabled his biographer to defend him against the virulent attacks of Flamsteed.

(See Brewster's *Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton*, Edinburgh, 1855, 2 vols.; and Edleston's *Correspondence of Sir Isaac Newton and Professor Cotes*, 1850.) (D. B.)

NEWTONIAN PHILOSOPHY, the doctrine of the universe, and particularly of the heavenly bodies, their laws, affections, &c., as delivered by Sir Isaac Newton.

The term *Newtonian Philosophy* is applied very differently. Some authors under this denomination include all the corpuscular philosophy, considered as it now stands corrected and reformed by the discoveries and improvements made in several parts of it by Sir Isaac Newton. In this sense it is that 'sGravesande calls his elements of physics *Introductio ad Philosophiam Newtonianam:* and in this sense the Newtonian is the same with the new philosophy, standing contradistinguished from the Cartesian, the Peri-

[1] See *Memoirs of Newton, &c.*, 1855, vol. ii., App., pp. 540–546.

[2] These papers have been more recently entrusted to Sir David Brewster, who has published the most important of them, in 1855, in the *Memoirs of Newton* above referred to.

[3] This volume was not published. The whole impression, which was small, was distributed in presents to scientific institutions, public libraries, and individuals interested in the subjects to which it relates.

Newton, Gilbert || Newton, John.

patetic, and the ancient corpuscular system. By Newtonian philosophy others mean the method or order which Sir Isaac Newton observes in philosophizing, viz., the reasoning and drawing of conclusions directly from phenomena, exclusive of all previous hypotheses; the beginning from simple principles, deducing the first powers and laws of nature from a few select phenomena, and then applying those laws, &c., to account for other things. And in this sense the Newtonian philosophy is the same with the *experimental* or *inductive philosophy*, and stands opposed to the ancient corpuscular system. By this philosophy some understand that particular kind in which physical bodies are considered mathematically, and where geometry and mechanics are applied to the solution of the appearances of nature. In this sense the Newtonian is the same with the *mechanical* and *mathematical philosophy*. Others, again, by Newtonian philosophy, understand that part of physical knowledge which Sir Isaac Newton has handled, improved, and demonstrated in his *Principia*. Lastly, by it is meant the new principles which Sir Isaac Newton has brought into philosophy, the new system founded thereon, and the new solutions of phenomena thence deduced, or that which characterizes and distinguishes his philosophy from all others; and this is the sense in which it ought to be used. (See the articles ASTRONOMY, ATTRACTION, DYNAMICS, OPTICS; Professor Playfair's Dissertation, part ii., sect ii.; and Sir John Leslie's Dissertation, sect. vii.)

NEWTON, *Gilbert Stuart*, an artist, was born at Halifax in Nova Scotia in 1794. His lessons in painting were begun at Boston under his maternal uncle, and were finished in London at the Royal Academy. The laborious and fastidious style in which he prosecuted his art soon brought him into notice. He first became known by his paintings of "The Forsaken" and "The Lovers' Quarrel," which were engraved in the *Literary Souvenir* for 1826. "The Prince of Spain's visit to Catalina" and "Macheath" raised him soon afterwards to the height of his reputation. His picture of "Abelard" followed in 1833. Shortly after this he became subject to mental aberrations, which grew in course of time into positive insanity. A few days, however, before his demise his reason returned, and he died in perfect consciousness at Chelsea in August 1835. Newton was a member of the Royal Academy. Some of his other pictures are,—"Shylock and Jessica," "Yorick and the Grisette," "The Abbot Boniface," "Portia and Bassanio," and "Lear attended by Cornelia and the physician."

NEWTON, *John*, an English divine, remarkable for his trials and adventures, and for the deep piety of his after life, was the son of a sea-captain, and was born in London in July 1725. After receiving a slight elementary education at a boarding establishment in Essex, he went to sea at the age of eleven; and from that time he was left to teach himself in the severe school of experience. The sensitive and thoughtful boy now became the prey of conflicting doubts and difficulties. For the next six years the religious impressions which he had received by the knee of his mother were in a continual struggle with the suggestions of atheistical books and scoffing companions. He became by turns a reader of the Bible and a student of Shaftesbury—a Pharisaical ascetic and a daring blasphemer—a remorseful penitent and a callous sceptic. At length, in his nineteenth year, his life assumed a more hopeful aspect. A passionate attachment which he then formed for a young Kentish maiden, who afterwards became his wife, began to restore the health and geniality of his heart; and his unexpected promotion in the following year to the rank of a midshipman on board the Havre man-of-war, afforded additional motives for good conduct. Yet the self-willed seaman soon entailed upon himself a long series of tormenting troubles. Taking it into his flighty brain to abandon his ship while she still lay at Plymouth, he was caught, brought back, flogged, and degraded. He set sail for India in 1745 a common sailor, taunted by his messmates, frowned upon by his superiors, and fuming with disappointment, remorse, and revenge. At Madeira a Guinea vessel took him in exchange for another. But in the course of six months he was fain to be landed a penniless adventurer on the African coast near Sierra Leone. Employment was soon found in the service of a slave trader in one of the Islands of the Plantanes. But the severity of the climate, and the cruelty of his master's black concubine, turned that employment into the most grovelling bondage. A year had not passed before the stout English sailor was transformed into a spiritless, half-naked wretch, suffering under the effects of fever, shivering under the wind and wet of the rainy season, devouring the nauseous roots which he stole by night from the plantations, or the fish which he caught by the sea-shore, and exciting the contempt and even the pity of the meanest of the slaves. Still more degrading did his condition become when he had been hired by a more merciful master. An English captain arriving at Sierra Leone in February 1747 with orders from his father to bring him home, found Newton herding contentedly with the Negroes in their low pleasures and gross superstitions; and it was only the thought of the fair maiden in Kent that could induce him to embark for his native land. The perils of this homeward voyage brought at length the severe moral training of Newton to a successful issue. On a March evening in 1748 he found himself on board a struggling and half-foundered vessel in the midst of the raging Atlantic; his sceptic indifference and blaspheming braggardism deserted him at the near prospect of death; the truths of the gospel, after a season of doubt, recommended themselves to his trembling spirit; and, when the ship reached Ireland four weeks afterwards, he stepped on shore an altered man. The life of Newton now for the first time became bright with the smiles of fortune. In 1750 his long-continued attachment to Mary Catlett was ratified by marriage, and he was shortly afterwards appointed commander of an African slaver. It was at this time also that those studies began to be prosecuted which trained and prepared his mind for the clerical office. On shore, during the intervals between his different voyages, and on deck when his ship was bounding before the breeze, he was fond of poring over Horace, Livy, Buchanan, and Erasmus. After a sudden stroke of illness in 1754 had forced him to exchange a seafaring life for the office of a landing waiter in the customs at Liverpool, he extended his studies to Greek and Hebrew, and the best theological works in Latin, French, and English. At length, in 1764, he was ordained, and was appointed curate of the parish of Olney. His pastoral labours were not followed by so much fruit as might have been expected. With his healthy piety, indeed, he did much to relieve the melancholy of the poet Cowper, and to form the religious opinions of the commentator Scott. But his kind-hearted liberality and his practical home-thrusts were alike spent in vain upon the senseless and profligate boors of the parish. It was not until he had been presented to the rectory of St Mary Woolnoth, London, in 1779, that he became one of the great instruments in dispelling the religious apathy of that age. The public were already in possession of his autobiography and of many of his letters; and they now began to regard him as a living proof of the efficacy of evangelical Christianity. This impression was increased and perpetuated by the earnest, simple-hearted zeal of his pulpit ministrations. He continued to preach thrice a week, even when he was bending under a weight of more than fourscore years, and his sight, hearing, and memory were fast failing. His friends entreated him to stop: "What!" he exclaimed, "shall the old African blasphemer stop while he can speak?" He died not long afterwards, in December 1807

Newton, John.

Newton, Thomas. || Newton-Ards.

A second edition of John Newton's works, containing his Autobiography, the *Omicron Letters*, the *Cardiphonia*, *A Review of Ecclesiastical History*, the *Olney Hymns*, and numerous sermons, discourses, tracts, and miscellaneous writings, were published in 6 vols. 8vo, London, 1816. His Life, by the Rev. Richard Cecil, was published in Cecil's Works, 4 vols. 8vo, London, 1811, and has also been printed separately.

NEWTON, *Thomas*, Bishop of Bristol, and Dean of St Paul's, was born on the 1st of January 1704. He was educated at Lichfield and Westminster; and had his university course at Trinity College, Cambridge, where he took his degree in arts, and attained to the rank of a fellow. He took clerical orders in 1729; and after holding a curacy at St George's, Hanover Square, London, he received his first preferment at Grosvenor Chapel, South Audley Street. In the spring of 1744 he was, through the interest of the Earl of Bath, his great friend and patron, presented to the rectory of St Mary-le-Bow. He took his doctor's degree in 1745; and in the spring of 1747 he was chosen lecturer of St George's, Hanover Square. In 1749 he published his edition of Milton's *Paradise Lost*, with notes from various authors, 2 vols. 4to, which was well received by the public, and by 1775 had gone through eight editions. His next performance of any note was his *Dissertations on the Prophecies*, 3 vols. 8vo, 1754-8; a work not characterized by very great profundity, either of thought or learning, but which nevertheless attained a wide popularity. They were translated into the German and Danish languages, and received the warmest encomiums from persons of learning and rank. In 1757 he was made prebendary of Westminster, dean of Salisbury, and sub-almoner to His Majesty. Four years afterwards he kissed the royal hand for his bishopric of Bristol; and in 1768 was made dean of St Paul's. Newton's health had never been robust; and after enduring great physical prostration for some time, he died in 1782, in the seventy-eighth year of his age. A complete edition of the bishop's writings, including numerous sermons and dissertations not referred to above, appeared, with an autobiography of the author, in 3 vols. 4to, London, 1782.

NEWTON, a township of England, county of Chester, situated on the slope of a hill, 8 miles E. by S. of Manchester, and 5½ N.E. of Stockport. It has a parish church in the Norman style, two Methodist churches, and several schools. The manufacture of cotton is carried on here, and employs the greater part of the population. Pop. (1851) 7481.

NEWTON-ABBOT, a market-town of England, Devonshire, pleasantly situated on a hill near the right bank of the Lemon, 14 miles S.S.W. of Exeter. It contains a handsome town-hall; a parish church; Independent, Baptist, and Methodist churches; and several schools. Tanning and shoemaking are the principal manufactures of the place; and there is also some trade, principally in the exportation of shoes to Newfoundland. The market-days are Wednesday and Saturday; and three yearly fairs are held here. In this place William III. made his first public declaration after his landing in this country in 1688. Pop. (1851) 3147.

NEWTON-ARDS, a seaport-town of Ireland, in the county of Down, situated at the head of Lough Strangford, 10 miles E. of Belfast. It is regularly laid out and well built, having a market-place, and a principal street lined with many good houses. The old church, now used as a court-house, though somewhat dilapidated, is a fine building, entered by a beautifully-carved Norman doorway. It was completed in 1632, though it probably existed before that time, and was then only repaired. The present church, an elegant building, was erected in 1817. There are numerous other churches, belonging to Presbyterians, Methodists, Roman Catholics, and Unitarians. Newton has also a large town-hall, with assembly-rooms in connection with it; several schools; a fever hospital, dispensary, and workhouse. The weaving and embroidery of damask muslins is the principal branch of industry carried on here; but there is also an extensive brewery in the town. In the neighbourhood there are some good stone quarries and lead mines. Pop. (1851) 9567.

Newton-in-Makerfield. || Newtown-Limavady.

NEWTON-IN-MAKERFIELD, or *in-the-Willows*, a market-town of England, county of Lancaster, 15 miles E. by N. of Liverpool, and about the same distance W. of Manchester. It has one principal street, which is broad, and lined with good houses; and on the site of the ancient market-cross an obelisk now stands. It possesses a neat parish church with a spire; an Independent chapel; and several schools. Cotton-mills, iron-foundries, glass-works, alkali-works, and brick-kilns are the principal manufactories, and give employment to the inhabitants. Races are held annually on a common not far from the town. Pop. 3126.

NEWTON-STEWART, a market-town of Scotland, county of Wigtown, on the right bank of the Cree, which is here crossed by a bridge of five arches, 7 miles N. by W. of Wigtown. It has a good town-hall; a large Gothic parish church; Free, United Presbyterian, Reformed Presbyterian, and Roman Catholic churches; and several schools. The inhabitants are employed to a large extent in the lead mines which are worked in the neighbourhood; and brewing, tanning, the manufacture of woollen and cotton stuffs, and the curing of bacon, are carried on in the town. Pop. (1851) 2199.

NEWTON-UPON-AYR. See AYR, *Newton-upon*.

NEWTOWN, a parliamentary borough and market-town of Wales, Montgomeryshire, pleasantly situated in a valley on the right bank of the Severn, here crossed by a stone bridge, 8 miles S.W. of Montgomery, and 175 W.N.W. of London. The streets are narrow, and the houses have a very mean appearance, being for the most part built of lath and plaster. The parish church is a building in the early English style, with a square tower, surmounted by a wooden belfry. There are also Baptist, Independent, Wesleyan, and Calvinistic Methodist churches; a theological seminary belonging to the Independents; besides several schools, a town-hall, and a handsome cloth-hall. The manufactures of the place are considerable, and rapidly increasing in extent and importance. Flannel is the principal article produced, and with this Newtown supplies a great part of Wales. There are also tanneries, malt-houses, potteries, and iron-foundries. Newtown joins with Montgomery and other boroughs in returning a member to Parliament. Pop. (1851) of the parish, 3784; of the borough, 6371.

NEWTOWN-BARRY, a village of Ireland, in the county of Wexford, is situated at the confluence of the Clody and the Slaney, 23 miles N.N.W. of Wexford. It is in the form of an irregular square; and has a good parish church with a tower and spire, a fine Roman Catholic church, several schools, a dispensary, and a fever hospital. Manufactures of linen are carried on; and slate, granite, and limestone are quarried in the vicinity. Pop. 1437.

NEWTOWN-HAMILTON, a town of Ireland, in the county of Armagh, is situated in a valley surrounded by steep hills, 11 miles S.S.E. of Armagh. It is ill built; and has a parish church, Roman Catholic and Presbyterian churches, and several schools. Some trade is carried on in flax. Pop. 1219.

NEWTOWN-LIMAVADY, a market-town of Ireland, in the county of Londonderry, is situated on the Roe, 13 miles S.W. of Coleraine, and 15 E.N.E. of Londonderry. It has a large parish church; three Presbyterian and two Wesleyan churches; besides Independent, Roman Catholic, and Unitarian chapels; several schools; a market house; jail; dispensary; work-house; and savings-bank. The manufacture

Newtown-Stewart || New York State.

of linen is carried on here; and there is a considerable trade in grain and flax. Pop. (1851) 3206.

NEWTOWN-STEWART, a market-town of Ireland, in the county of Tyrone, 9 miles N. by W. of Omagh, contains many well-built houses; a large parish church; Presbyterian, Wesleyan, and Roman Catholic churches; a school; a dispensary; and the ruins of an old castle. Pop. 1405.

Extent and area.

NEW YORK, one of the United States of America, is situated between Lat. 40. 30. and 45. N., and (including Long Island, &c.) between Long. 71. 51. 58., and 79. 55. It is bounded N. by Lake Ontario, St Lawrence River, and Canada East; E. by Vermont, Massachusetts, and Connecticut; S. by the Atlantic Ocean, New Jersey, and Pennsylvania; and W. by Pennsylvania, Lake Erie, and Niagara River. Its form is irregular, but may be compared to that of an irregular triangle, with its apex touching the Atlantic. The extreme length east and west of its continental part is about 335 miles, and the extreme breadth north and south about 308 miles. Including Long Island, Staten Island, &c., the total area of the state is computed at 47,000 square miles, or about one sixty-third of the entire area of the United States.

Islands.

Long Island, the largest insular portion of the state, projects into the Atlantic (opposite, and in the main parallel, to the shore of the mainland, the most of which is embraced by Connecticut), a distance of about 125 miles; its greatest breadth is about 20 miles, its average breadth 12 miles, and its area about 1440 square miles. Staten Island, at the mouth of New York harbour (and included in Richmond county), is about 14 miles long, from 4 to 8 miles wide, with an area of about 60 square miles. Manhattan Island (embraced in New York city and county) has an extreme length of 13½ miles, an average breadth of 2 miles, and an area of 21¾ square miles. In New York harbour are three islands—Governor's, Elles', and Bedlow's, ceded to the United States government, and fortified. In the East River, or Strait of Long Island Sound, are three islands occupied by New York city institutions. In Niagara River, about 4 miles above Niagara Falls, is Grand Island, having an area of 27 3/16 square miles, besides several small islands.

Physical aspect.

The surface of the state is considerably elevated, the larger part of it being a section of the great Alleghany table-land. There is, however, a great diversity in the aspect of the several physical divisions. The eastern half of the state is traversed by ranges of mountains; the interior has an uneven surface, and contains several large and deep lakes; and the western part, though frequently uneven, is distinguished for its broad and rich plains. There

Natural divisions. Atlantic district, or Long Island.

are four great natural divisions,—1. The Atlantic district, the smallest of these, comprises Long Island, which is a low sandy region, with extensive plains rising along its northern borders into hills of moderate elevation, at but one point only exceeding 300 feet in height. Its temperature differs much from that of the mainland. Its insular position, and its early settlement, have occasioned the extirpation of the larger quadrupeds; and it is more remarkable for the abundance and variety of its birds, than for the number of its mammalia. It forms the southern limit of the migrations of the arctic species of birds, and the northern limit to those of the torrid zone. It seems also to be the boundary between the fishes and other classes of the northern and tropical seas. 2. The Hudson valley district comprises the region watered by the Hudson River and its tributaries, the chief of which is the Mohawk River. The outline bears some resemblance to the letter L inverted (thus, ⅂), the perpendicular and main part of the letter representing the Hudson River, and the horizontal and minor part of it representing the Mohawk River. The latter, after an eastward course of 140 miles, enters the Hudson at a distance of 160 miles from the Atlantic. This district is traversed by ranges of the Alleghany Mountains, and its western border embraces the Catskill range of mountains, some of which are nearly 4000 feet high. In regard to size, this is the third of the four districts. 3. The Northern district lies N. of the Mohawk valley, is bounded W. by Lake Ontario and the River St Lawrence, and has the shape of an irregular truncated triangle. Its south-eastern half embraces the region of the Adirondack Mountains, estimated to contain an area of about 6000 square miles, and containing numerous conical peaks and short ranges, reaching in some places an elevation of more than 5000 feet. Towards Lakes Champlain and George they subside suddenly to the level of those sheets of water. To the N. and N.W. there is a very gradual slope towards the River St Lawrence. 4. The Western district includes the region between Lakes Ontario and Erie on the N., and the Pennsylvania boundary-line on the S. A large proportion of it is elevated and furrowed by valleys, extending N. and S., which give rise to rivers pursuing opposite directions. Its central position is a level table-land, rising in its southern parts to elevations of from 1000 to 1200 feet above the sea, and abruptly subsiding on its western border to the level of Lake Erie. This same portion contains a series of lakes, stretching generally from N. to S., varying from 15 to 38 miles in length, and discharging their waters by one common outlet, the Oswego River, into Lake Ontario. Lakes Erie and Ontario exercise a great influence on the climate and other features of this district, the whole of which is exceedingly fertile, and in its uncultivated portions is covered by a vigorous growth of forest trees.

New York State. Northern district. Western district.

Mountains.

The Alleghany Mountains enter the S.E. part of the state by two distinct ridges from New Jersey and Pennsylvania. The former crosses the Hudson River at West Point, forming the highlands of the Hudson, celebrated for their scenery, which combines grandeur with the most picturesque beauty. At this crossing the highlands are from 15 to 20 miles in breadth, and have a height of about 1400 feet, and in one instance, on the E. bank of the river, near Fishkill, they attain an elevation of nearly 1700 feet. East of the Hudson this range has a N.E. direction, until it approaches near the Connecticut boundary-line, and then extends N., being called the Taconic range, until it merges in the chain of the Green Mountains. The second branch of the Alleghanies, leading from Pennsylvania, is the range of the Shawanzunk Mountains, which also extends in a N.E. direction, approaching the Hudson, but not crossing it. The Catskill range approaches the Hudson by a similar course, and extends parallel to it for 20 miles, but then bends off to the N.W., towards the Mohawk River. The mountains in the northern part of the state, which are together generally called the Adirondack Mountains, comprise several ranges which have distinct local names; but they constitute a cluster which may be considered as a branch of the great Appalachian system. In other sections there are ranges of hills and highlands.

Rivers.

The most important river for purposes of general navigation exclusively within the state, is the Hudson, which is also one of the most magnificent water-courses in the New World. It rises, by two branches, among the Adirondack Mountains, and having received the Sacandaga, pursues its course (of about 160 miles from its sources) to Waterford, 10 miles above Albany, where it receives the Mohawk River, and thence flows almost directly southward about 156 miles, to its entrance through New York Bay into the Atlantic Ocean. To Troy, 151 miles from the city of New York, the tidal wave passes in from seven to nine hours from New York; and to that city the river is navigable for large steamboats of light draught. Ocean vessels do not ascend above Hudson, 118 miles from New York. The River St

New York State.

Lawrence, the outlet of the great lakes, forms a large part of the northern boundary of the state, and conveys to the ocean a larger volume of water than any other river in the world, except the Amazon. It is navigable for sloops to Ogdensburg, 60 miles from Lake Ontario, but below that place its navigation is much interrupted by rapids. Several rivers of great volume, lying within the state, have each a course of above 150 miles; and, in addition to their natural service in draining and watering their respective valleys, afford, from their descent, most valuable water-power, which latter circumstance prevents continuous navigation by vessels of considerable size.

Falls and cascades.

The falls and cascades of the rivers of this state are numerous, forming notable features in its scenery. The great Falls of Niagara are elsewhere described. The Genesee River has a series of falls; near its sources it descends, within the space of two miles, by three falls of 60, 90, and 110 feet, through a wild and picturesque gorge, formed in the solid rock to the depth of 400 feet; and at Rochester it again descends by three falls of 96, 20, and 105 feet (making, with two rapids, a total descent of 268 feet within the city's limits), the first of which, by its affording immense water-power, has been a principal cause of the prosperity of that flourishing city. Fall Creek, near Ithaca, descends 438 feet; in the space of one mile, by several cascades, one of which has a perpendicular pitch of 116 feet. The Mohawk River in its falls at Cohoes is precipitated over a broken rock 62 feet high, the bank of the river forming precipitous walls 140 feet above the stream; and at Little Falls, some miles above, it passes through a fissure in the rocks, which rise on each side 500 feet above its surface. Trenton Falls is a series of cascades and rapids in West Canada Creek, a tributary of the Mohawk, and 15 miles N. of Utica, extending over 2 miles in a narrow channel cut through solid limestone rock, the sides of which in places rise perpendicularly to the height of 140 feet. At Glenn's Falls, 18 miles from Saratoga, the Hudson flows over a precipitous ledge of rocks, with a descent of 70 feet. In various other rivers, especially in the northern part of the state, there are many waterfalls of much beauty, which are also of importance from their furnishing motive power.

Lakes.

The great exterior lakes, Ontario and Erie, are navigable for the largest steamers and sailing-vessels, and each has several good harbours. Lake Champlain, between this state and Vermont, is 134 miles in length, and of comparatively narrow though unequal width, but is navigable throughout its length for steamboats of the first class. The lakes in the interior of the state not only constitute an interesting feature in its physical geography, but they are of considerable importance to commercial navigation. The largest of these which are navigable by steamers are Lake George, 36 miles long; Cayuga, 38; and Seneca, 35; after which are Oneida Lake, 20 miles long; Skaneateles, 16; Crooked, 18; Canandaigua, 15; Chautauque, 18; and several others. The northern district of the state abounds with small lakes, there being perhaps 200, some of which are greatly elevated above the sea.

Lake harbours.

The harbours of Buffalo and Dunkirk, on Lake Erie, are capacious, and are also important commercial stations, forming the termini of the two great lines of railroad which extend through the whole length of the state to the Hudson River. On Lake Ontario there are several good harbours,—viz., Sackett's Harbour, Oswego, Genesee (port of Rochester), Niagara, &c.; the first of which is the best, and was an important naval station during the war of 1812–14. Lake Champlain has some harbours, which are sufficiently commodious for the shipping on that lake.

Sea-coast.

The sea-coast of the state is nearly all comprised in the shores of Long Island, which contain a few harbours and inlets, but none that are much frequented by shipping. The bay and harbour of New York are subsequently described.

New York State.

Survey of the state.

The legislature of New York, by its act of 15th April 1836, authorized a complete geological survey of the state, which should furnish a perfect and scientific account of rocks and soils, and their localities, with a list of all its mineralogical, botanical, and zoological productions, and which should also procure and preserve specimens of the same. In the execution of that act, and of the acts of May 18, 1840, and of April 9, 1842, the survey was made. The final report on the results of the survey consists of sixteen large quarto volumes, abundantly and splendidly illustrated. There are eight several collections of specimens of the animals, plants, soils, minerals, rocks, and fossils, found within the state, one of which collections constitutes a museum of natural history at the capital of the state, and the others are distributed among its collegiate institutions. A geological map is also published, and several more volumes are expected upon the palæontology. The total cost of the survey and of printing, &c., has been estimated at about L.145,000.

Geology.

With the exception of the alluvial and diluvial deposits, and the beds of Tertiary on the St Lawrence, occupying a very limited area, all the formations of the state of New York are older than the coal formation. The lowest rock of the coal formation occupies some small patches in the south-western part of the state; but none of the coal-bearing strata approach nearer than within six miles of the state line. The prevalence of limestone in nearly all the formations is worthy of notice, affording as it does the basis rock best adapted to yield the materials for fertilizing the soil.

Primary system.

There are two tracts of rocks of the Primary system (comprising the unstratified crystalline and the stratified non-fossiliferous), which together occupy about one-third of the area of the state, and are separated from each other by the intervention of a narrow belt of sedimentary rocks. The first is in the north-eastern part of the state, and is of irregular circular form, occupying the counties of Essex, Warren, and Hamilton, with parts of the adjoining counties embraced in the region of the Adirondack Mountains. Nearly the whole of the county of Essex, with its lofty mountains, is composed of hypersthene rock, a compound of Labrador felspar and hypersthene, allied to syenitic granite. In this region it is associated with very large deposits of magnetic iron ore. Throughout this northern section primitive limestone, important for the manufacture of lime for agricultural purposes, is quite abundant. The second tract of the Primary formation consists of a comparatively small section, somewhat triangular, in the southern and south-eastern portion of the state, comprising the counties of Putnam and Westchester, with the larger part of New York, and parts of Rockland, Orange, and Dutchess. The predominant rock in both these Primary sections is gneiss, which furnishes a fine building material, and, under the popular name of granite, is extensively quarried, varying, however, in appearance and composition in different sections. Granite exists, but it is quite unimportant both in extent and value.

Taconic system.

The term Taconic system has been given to that series (comprising seven groups, according to the New York geologists) denominated metamorphic, lying between the most decided crystalline slates and the lowest fossiliferous rocks. (This system, according to Professor Emmons, is fossiliferous, distinct from and lower than the New York system, and corresponds to the Cambrian rocks of Great Britain; but according to others, it is the New York system metamorphosed by heat.) The term is derived from the Taconic or Taghkannic range of the Appalachian chain, on the eastern boundary of the state, in which is the principal deposit; but there are extensive deposits of similar character all along the west side of the Green and Hoosac Mountains of New England, and so through the Appalachian ranges to Alabama, besides thinner ones in many other places throughout the United States, making in all a series of rocks many thousand feet thick and many hundred miles long. Its seven groups or formations are,—granular quartz (which furnishes white siliceous sand for glass and sand-paper, and for sawing marble), Stockbridge limestone, magnesian slate, sparry limestone, roofing slate, Taconic slate, and black slate. The limestone is fine, furnishing good building material.

New York system.

The New York geologists denominate as the New York system that whole series of rocks which are identical with the lower and upper Silurian of Europe, including two or three members of the Devonian group; and this system they divide into four principal groups, and subdivide into twenty-eight minor groups. Other American geologists have given other names to these series. Our limits allow only a synopsis of their extent in the state of New York, and brief allusion to their characteristics. The four principal groups are named Champlain division, Ontario division, Helderberg series, and Erie division.

The Champlain division, the lowest of the four, corresponding to

New York State.

the Lower Silurian (or Cambrian or graywacke) system of Europe, embraces eight formations. It occupies a very considerable but irregular territory. It extends along the St Lawrence, commencing from its mouth, to its source in Lake Ontario. A branch runs southerly along the east side of the granitic mountains of Essex, &c., along the borders of Lake Champlain, and thence south-westerly to Alabama. These rocks, indeed, flank the mountains of Essex county, &c., so as to form a huge granitic island, giving us an idea of the state of things when the Silurian rocks were in course of deposition. Its lowest formation,—viz., the Potsdam sandstone, is supposed to be the lowest fossiliferous rock in the world. The most common shell in it is a lingula, a genus which has survived all the revolutions of the earth, and is still found in the ocean. This formation, 300 feet thick, furnishes a beautiful and durable building material. The other formations (in ascending order), and their estimated thickness, are—calciferous sand-rock, 300 feet, in which fossils are both rare and obscure; Chazy and Black River limestones, 100 feet, some of which produce fine dark-coloured marbles, as well as good quick-lime; Trenton limestone, 400 feet, rich in organic remains; Utica slate, 100 feet, employed in roofing; and the Hudson River group, embracing the gray sandstone, 700 feet, which furnishes stone suitable for grindstones.

The Upper Silurian of Europe embraces the two highest members of the Champlain division, all the Ontario division, and more than half of the Helderberg series of the New York geologists; and its thickness is about 2400 feet. In New York the Upper Silurian rocks extend in a belt of nearly equal width along the south side of Lake Ontario (and in Canada on the north side of Lake Erie), whence it spreads out southerly and westerly over more than half of the Western States. The lowest of this system is the Oneida grit, which is 500 feet thick, coarse and fine grained, and almost destitute of organic remains. Next to this are the formations comprised in the Ontario division of the New York system,—viz., Medina sandstone, Clinton and Niagara groups, and the Onondaga Salt group. The Medina sandstone, 350 feet thick, is a red or variegated siliceous mass, sometimes marly and friable, interstratified with gray bands of quartzose sandstone. The Clinton group, 80 feet, is composed of red and variegated shales and sandstones, so diversified as to have received the name of Protean, and it abounds in fossils. The Niagara group, 264 feet, consists of shale below and limestone above. The former, exposed to atmospheric and aqueous action, crumbles away and leaves the limestone in overhanging masses, which at length break by their own weight. These are the rocks over which the water at Niagara Falls is precipitated, and this is the cause of their retrocession. This formation is highly fossiliferous. The Onondaga Salt group, from 600 to 1000 feet thick, is an immense mass of argillo-calcareous shaly rocks, abounding in veins and beds of gypsum, and the source of all the salt springs in New York and the Western States. Notwithstanding its great thickness, it is very barren in fossils. This Ontario division occupies a strip about 20 miles in width, and nearly equal in length to Lake Ontario, which bounds it on the north. The remaining varieties of the Upper Silurian (placed by Professor Hall under the name of the Lower Helderberg limestones) are—the Water Lime group, 100 feet thick; Pentamerous limestone, 80; Delthyris limestone, 200; and Upper Pentamerous limestone. The last named (with the following:—Oriskany sandstone, 700 feet thick—in Pennsylvania; Cauda Galli grit; Schoharie grit, or sandstone; Onondaga limestone; and corniferous limestone, 70) constitute the Helderberg series (of the New York system), which is most fully developed in Albany and Schoharie counties. The Helderberg limestone is cavernous; and some of its caves are celebrated for their extent, containing stalactites and stalagmites of great variety and beauty.

The formations last enumerated with the Erie division of the New York system (which consists of the following;—Marcellus slate, 50 feet thick; Hamilton group, 1000; Tully limestone, 20; Genesee slate, 250; Portage or Nunda group, 1000; Chemung group, 1500; and the Old Red sandstone, perhaps 3000—making a total thickness of about 7000 feet) constitute the Devonian system; or Old Red sandstone of Europe. The Erie division is divisible into two parts, the lower, called the Ludlowville shales, consisting of shales upon thin beds of limestone, most of them quite decomposable, occupying a belt, nearly 20 miles in width, through the central portion of the state; and the upper, called the Chemung group, consisting of thin, even beds of gray sandstone, with intervening shales, occupying the whole of the southern tier of counties. Thus it appears that in New York the Devonian system occupies the southern half of that portion of the state which extends between the Pennsylvania boundary-line on the south, and Lake Ontario and the Mohawk River on the north. The Old Red sandstone proper is confined chiefly to the Catskill Mountains, which are mainly composed of it. It consists of various strata of sandstone, shale, and shaly sandstone, the sandstones being of a red or reddish colour.

Tertiary formation.

The clays and sands of the tertiary formation skirt the shores of the St Lawrence, Lake Champlain, and the Hudson, consisting of a stiff blue clay beneath, a yellowish-brown clay in the centre, and sand above.

New York State.

Minerals.

Iron ores are abundantly distributed through the north-eastern and south-eastern sections of the state, especially in the former. In Clinton and Essex counties, the deposits of magnetic iron ore, the black oxide, form beds of from 1 to 20 feet in thickness, almost without mixture, encased in granite; they are also found in the mountains of that region, and appear to extend without interruption into New York from Canada. The Stafford vein in Essex county was estimated in the geological survey to contain ore sufficient to yield three million tons of malleable iron. The specular oxide is found chiefly in the counties of St Lawrence, Jefferson, and Franklin, which border the St Lawrence River. In the south-eastern section there are extensive beds of both magnetic and hematite ores, but the latter is the more abundant. The carburet of iron occurs abundantly in the same section, and less abundantly in the north-east section. Lead ores occur in considerable deposits in various sections, of which by far the most extensive and celebrated are those in the town of Rossie, in St Lawrence county. In 1837 and 1838 these yielded nearly 3000 tons of metallic lead; but they have not been regularly worked to that extent. There are small veins of zinc, copper, &c., in several counties. The Onondaga salt springs, at and around Syracuse, are the most important in the Union; they have been worked since 1797, and the amount of their product has increased with nearly every successive year. The number of bushels of salt made in 1854 was 5,803,347; in 1855, 6,082,885; and in 1856, 5,966,810. Mineral springs, celebrated for their medicinal value, and as places of great resort in the summer, exist in various districts. The central, and some of the western counties, contain abundance of gypsum, which is largely used as a fertilizer, and extensively exported. The abundance of excellent building material has already been noticed. The petroleum springs, in the counties of Cattaraugus and Alleghany; the nitrogen springs of New Lebanon and Hoosac; and the carburetted hydrogen springs, in the neighbourhood of Lake Erie and Niagara River, are also worthy of notice. There are several springs of the last-named class in the county of Chautauque, one of which affords gas that is used to light the houses in the village of Fredonia, while another supplies the lighthouse in the village of Barcelona.

Soils.

The soils of this state are so very various, that a full and correct description of them, within our limits, is impossible. In general terms, the most of the soils, or the greater portion of the surface of the state, may properly be called very fertile. The sections least fertile are in the north-east part, traversed by the mountains, where much of the surface is poor and cold; and yet there are many productive valleys in that region. The valleys of the Hudson and Mohawk comprise tracts of excellent soil, but they are greatly surpassed in extent and fertility by the western parts of the state, especially by the section known as the Genesee Flats.

Climate.

The different sections of the state have considerable diversities of climate, each being marked by its own peculiarities. Taken altogether, the climate of the state is everywhere one of great extremes, and subject to sudden and severe changes at all times of the year. Notwithstanding this, however, it appears that the state as a whole is very healthy. The mean average temperature of the whole state is 46°·49 Fahr.; mean maximum 92°, mean minimum 12° below zero, and the mean annual range 104°. The southern section of the valley of the Hudson, and the whole of Long Island, are the most equable portions of the state. The Mohawk valley has a climate which does not vary greatly from the mean average. The region N. and E. of the Mohawk is characterized by a low average tem-

New York State.

perature, backward seasons, and early frosts. The western or lake region has a similar climate to that of Long Island. Summarily, this state has the summer heats of Spain and Italy, and the rigour of its winter is equal to those of the northern portions of Europe.

Vegetation.

Corresponding to the varieties in its characteristics of surface, soil, and climate, we find, as we should expect, that this state has an exceedingly diverse vegetation. Within its borders are trees, shrubs, grasses, &c., of both extremes of the States—the north and the south. Its most important natural growth is that of its forest trees, which once covered its whole territory, and yet occupy the immense tracts that have not been brought under cultivation. The most common trees in the forest are the varieties of oak, pine, beech, &c.; but scarcely any variety, found under similar latitude and climate, is wanting. The mountain sides and woods are clothed with a shrubby undergrowth. The native grasses are numerous and widely distributed, but only a few of them are valuable, and the cultivated meadow grasses are of foreign origin. The whole number of flowering plants in the state is about 1450,—of which 1200 are herbaceous, and 150 may be regarded as ornamental. Of woody plants, there are 250 species, including 80 that attain to the stature of trees. Of plants that are reputed medicinal there are, native and naturalized, about 160 species.

Zoology.

From the diversity of the climate, which exercises a great influence upon the number and distribution of its animals, it results that its classes of the animal kingdom comprise those found in both the northern and southern portions of Europe. The families *Cervidæ* and *Mustelidæ* may serve as examples of the one; while the *Vespertilionidæ* and *Muridæ* will illustrate the other. The previous explanation of the natural divisions of the state points out the four principal zoological districts, each sufficiently distinct in itself, but of course so much blended at the lines of separation as not to be contradistinguished. The forests were formerly ranged by the moose, stag, and reindeer, but these are now seldom met with. The existing animals are the American deer, black bear, puma, &c., descending in size to the hares, squirrels, and smaller quadrupeds. The Mastodon has been found in a fossil state in several places; the most perfect and gigantic skeleton being that found in 1845 near Newburgh, Orange county, weighing 2000 lbs., and owned by Dr John C. Warren of Boston, by whom it has been described in one of the memoirs published by the Smithsonian Institution. Teeth and other remains of elephants, &c., have been occasionally dug up. Of birds of prey the species are numerous; of birds of passage, 20 different tribes and 149 species; of the Scansoriæ, the genus *Picus* (woodpecker) is very common; of the Gallinaceæ, several species; of the Grallatoriæ, or waders, there are 62 species in 7 families; and of the Palmipedes, or swimming birds, there are many varieties. In regard to the Reptilia, Amphibia, Pisces, Mollusca, Crustacea, and Insecta, we have not room for even a condensation of the results of the survey of the state.

The aborigines and their antiquities.

The state of New York, in common with other portions of North America, possesses many interesting but obscure traces of once powerful nations, which seem to have existed previous to those savage tribes who occupied the country at the period of its discovery by Europeans. The ruins of fortifications, mounds, &c., the traces of agriculture, and the remains of rude art which have been brought to light in various parts of the state, display marks of high antiquity, and bespeak the existence of a people entirely distinct from the Indians who were found here by the first European discoverers. These works consist chiefly of earthen parapets, the sites of which, with a view to defence, appear to have been selected with much judgment; and greater skill was exercised in their construction than has been displayed by the Indian races known to us. The forms of these remains are various, being circular, elliptical, triangular, and square; and they are generally placed in situations which command the adjacent country. Near many of the forts are mounds of earth raised for cemeteries, in which human bones, in various stages of decay, are common. These may have been the burial places, in some instances, of the more recent Indian tribes. The number of forts and mounds in the western part of the state much exceeds 100. The inclosed areas of the fortifications vary from 6 acres to 100 feet in diameter; and the earthen walls which inclose them, in their present abraded condition, are from 10 to 12 feet in height, and from 6 to 8 feet in breadth. Some of these breastworks bear or have borne trees, whose age has been estimated at more than two hundred and seventy-five years, and which may have been preceded by others. There are indications that the architects of these works were not so greatly advanced in civilization as the Toltecs or Aztecs of Mexico, and thus their origin is surrounded with additional mystery.

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Indian tribes.

At the time of the first settlement of New York, the principal Indian tribes in the region now comprised in the state were those of the celebrated confederacy of the Five Nations, viz., the Mohawk, Oneida, Seneca, Onondaga, and Cayuga. It is asserted by a writer in 1741, that this confederacy was established, as the Indians say, one age or one man's life before the white people settled at Albany (1615), or before white men came to the country. Long before they were known to the Europeans, these nations had acquired a decided superiority over other Indians; and this they long retained, extending their conquests as far as South Carolina. In 1714 they were joined by the Tuscaroras, and from that time the confederation was known as that of the Six Nations. In 1608 Champlain, by his attack, had rendered them hostile to the French, and their hostility continued until the French lost Canada. Their alliance with the English continued so firm, that on the breaking out of (and in fact before) the Revolutionary war, they were induced to engage against the Americans. The Six Nations then numbered about 10,000, and had 2000 bold and skilful warriors. Including these, there were, within the Indian department of the northern provinces, 130,000 Indians, of whom 25,420 were fighting men. But if their employment by the British government was disastrous to the Americans, it was equally so to the Indians. A considerable portion of the Oneidas refused to join with the other tribes against the colonists. The bond of this confederacy was severed never to be reunited. The war made sad havoc with their warriors, and at its close the remnants of the tribes passed away before the influx of settlers. In 1788 and 1789 the Six Nations, by treaty, conveyed to the state a large tract of their territory; and by other purchases, &c., the Indian title to nearly all lands in the state was extinguished. Certain reservations, chiefly in the western counties, were made, portions of which the Indians and their descendants have continued to hold to the present time. Their total number in 1845 was 3753; in 1855, 3934.

Discovery in 1609.

The history of New York commences with 1609. On the third day of September in that year, Henry Hudson, an Englishman by birth, in the service of the Dutch East India Company, anchored his vessel, the Crescent, within Sandy Hook. Almost at the same time Champlain was invading New York from the north. After a week's delay, Hudson sailed (Sept. 11) through the Narrows, and anchored in New York harbour. Ten days (Sept. 12th to 22d) were employed in exploring the river. Hudson, the first of Europeans who penetrated so far into the country, went sounding his way beyond the Highlands, till the Crescent had sailed some miles above the city of Hudson, and a boat had advanced a little beyond Albany. Frequent intercourse was held with the astonished Indians. Having completed his discovery, Hudson descended the

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stream to which time has given his name; and, on the fourth day of October, set sail for Europe.

Early Dutch traffic.

The right of possession of the country was claimed for the United Provinces; and, in 1610, merchants of Amsterdam fitted out a ship with various merchandise to traffic with the natives. The voyage was prosperous, and was renewed. In 1614 the first rude fort was erected—probably on the southern point of Manhattan Island. In the next year (1615) the settlement at Albany was begun, on an island just below the present city. This was the remote port of the Indian trader, and was never again abandoned. Yet at this early period there was no colony; not a single family had emigrated; the only Europeans on the Hudson were commercial agents and their subordinates. The Dutch West India Company was incorporated, June 3, 1621, for twenty-four years, and became the sovereign of the central portion of the United States, though colonization on the Hudson was neither the motive nor main object in its establishment. Its first ship arrived in the harbour of New York in 1623. This is the era of the permanent settlement of the country, which in its development shortly assumed the form of a colony.

Colonial history.

In 1624 Peter Minuits, the commercial agent of the West India Company, arrived with several families, and thenceforward held the office of director (governor) until 1633, when he was succeeded by Wonter Van Twiller, who in 1638 gave place to William Kieft. During the administration of the latter, the colony was troubled by controversies with the encroaching English, and suffered from the provoked hostilities of the Indians. In 1647 Peter Stuyvesant became governor, and by his exertions a provisional treaty was made with the surrounding English colonies. In 1664 Charles II. granted to his brother James, the Duke of York, the territory claimed by the Dutch. On 8th September of that year, Colonel Nichols, commissioned for the purpose, compelled Stuyvesant to surrender, and changed the name of New Netherlands to New York. In 1673 the Dutch retook the colony, but in the next year they finally surrendered it to the English, who held possession until the American Revolution. During this lengthy period New York suffered much from the Indian depredations and ravages in the wars waged between the French and English. In 1690 Schenectady was burned by the savages, and many of its inhabitants massacred. Apart from these wars, no very important event occurred for many years preceding the negro plot in 1741. On 7th October 1765, the first continental congress of the colonies met in New York city; and from that time, until the close of the Revolution, the general history of New York is almost identical with that of the united colonies.

Events of the Revolution in New York.

A considerable portion of the active hostilities of the revolutionary war took place on the soil of this state. At its commencement the American militia captured Ticonderoga, Crown Point, and Whitehall, and thus secured the command of Lake Champlain. The most prominent occurrences in New York were,—the defeat, in the autumn of 1776, of the Americans on Long Island and at White Plains; the surrender, on 17th October 1777, of Burgoyne, the British general, with his 6000 troops; and the capture, on the 16th July 1779 of Stony Point by the Americans, under General Wayne. Jay, Hamilton, and others distinguished in the national councils, were natives of New York.

Formation of State government.

The colonial government was suspended in May 1775, from which time, to 20th April 1777, a provincial congress governed; of which Nathaniel Woodhill was president from August 1775. On 9th July 1776, the fourth session of this body met, by adjournment, at White Plains, and having received the Declaration of Independence, approved it. On 12th March 1777, a constitution for the state was reported by a committee of the congress; on the 20th April following it was adopted; and it so remained through the war, and afterwards. On 26th July 1788 it was ratified by the state legislature, and it thence continued to be the organic law, without change (excepting a few amendments in 1801) until 1821, when it was revised by a convention elected for that purpose; and their revision was duly ratified by the people. In 1846 a new constitution, prepared by a convention, was approved by the people; and to this was made, in 1854, an amendment relative to the public debt.

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Government. Abstract of the Constitution.

The present constitution came into operation 1st January 1847. The right to vote is granted to every white male adult citizen resident of the state one year, of the county four months, and of the election district thirty days; and to coloured persons having paid tax on freehold estate of L.52, and been citizens for three years. General elections are held on the Tuesday after first Monday in November. The legislature assembles on the first Tuesday in January. Senators (32) are elected for two years; assembly-men (128) for one year; and both receive 12s. 6d. per diem for a hundred days' session, with mileage. The Judiciary is thus constituted:—The court for the trial of impeachments consists of the senate and the judges of the court of appeals, and its judgment extends only to removal or disqualification for office, with liability to indictment. The court of appeals is composed of 8 judges, of whom 4 are elected by the electors of the state, and 4 are selected from the justices of the supreme court having the shortest time to serve, and its chief judge is chosen from those elected. The supreme court, having general jurisdiction in law and equity, comprises 8 districts, in each of which 4 justices are elected for eight years. County courts (except New York county) consist of 1 judge, elected for four years. Municipal courts have uniform organization and jurisdiction; justices of the peace are elected for four years. Any male adult citizen of good morals, and requisite ability, may practice in all state courts. The governor, elected by the people for two years, must be thirty years old, state resident for five years, and United States citizen. Of the administrative officers, the secretary of state, comptroller, treasurer, attorney-general, and state engineer, are elected by the people for two years.

Finances.

In 1814 the state had a fund applicable to the support of its government, amounting to L.916,017. In 1817 the construction of the Erie and Champlain canals was commenced; and in defraying their cost the public monies were exhausted, and a debt was created. Before the year 1835 the state had formed 656 miles of canal, at a cost of L.2,427,631, of which the Erie Canal, 364 miles long, cost L.1,488,285. The public debt, though it has been gradually increasing, has never been a burden to the taxpayers of the state; since the receipts from the tolls, &c., of the canals, have not only paid the expenses of the canals and a large share of the ordinary expenses of government, but have earned a surplus, used in discharging the interest of the debt. On 30th September 1856, the total canal debt was L.4,670,056. The work of enlarging the canals, which, for several years, has been in progress, has resulted in an increase of the canal debt; but, it is confidently believed, that when this is completed, the canals will amply repay all the cost of construction and maintenance, and thereafter, afford a large revenue to the state. In 1856 the assessed value of taxable property in the state was nearly L.292,000,000; but this assessment, as in all the states, is much below the real value.

Population.

The following table exhibits the result of the census of New York during the period preceding the War of Independence:—

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Years.	Whites. Male.	Whites. Female.	Blacks. Male.	Blacks. Female.	Total Population.
1698	8,143	7,754	2170		18,067
1703	9,322	9,085	1,174	1084	20,665
1723	17,583	16,810	3,364	2807	40,564
1731	24,856	18,205	4,866	2897	50,824
1737	25,740	25,756	4,948	3993	60,437
1746	26,860	25,622	4,857	4250	61,589
1749	32,355	30,401	5,696	4896	73,348
1756	43,261	39,981	7,570	5978	96,790
1771	73,990	69,484	10,623	9240	163,337

In 1774 it was estimated that the colony of New York embraced a population of 161,098 whites, and 21,149 blacks; or 182,247 in all. Of the enumerations in 1776 and 1782, only fragments now remain. In 1786 a full census gave to the state a total of 238,897; of which there were 219,956 whites, 18,889 slaves, and 12 Indians paying taxes. The following table is a synopsis of the enumerations of the state from 1790 to 1850, taken by United States' authority:—

Date of Census.	White Persons.	Coloured persons. Free.	Slave.	Total.	Total Population.
1790	314,142	4,654	21,324	25,978	340,120
1800	556,039	10,374	20,343	30,717	586,756
1810	918,699	25,333	15,017	40,350	959,049
1820	1,332,744	29,980	10,088	40,068	1,372,812
1830	1,873,663	44,870	75	44,945	1,918,608
1840	2,378,890	50,027	4	50,031	2,428,921
1850	3,048,325	49,069	0	49,069	3,097,394

The increase of population in this state during these sixty years was not only greater in absolute numbers, but was also greater in proportion than in any other of the free states, the ratio having been 810·68 per cent.; while Maine, which exhibited the next greatest growth, increased its population 504·07 per cent. during the same period. On 1st June 1855, the population had increased to 3,466,212; of which there were 45,286 coloured persons.

Origin of population.

The state census of 1845 first directed inquiries concerning place of birth, which were of a general character. Similar, but more minute inquiries, were made in the national census of 1850, and still more careful investigations in the state census of 1855. A synopsis of the returns of the three periods thus presented:—

Place of birth.	1845.	1850.[1]	1850.[1]	1855.
State of New York	1,894,278	2,129,651	2,151,196	2,222,321
New England States (6)	228,881	307,120	206,630	207,539
Other United States	83,642		81,470	98,584
Total United States	2,206,801	2,436,771	2,439,296	2,528,444
Foreign countries	347,266	655,929	651,801	920,019
At sea	...	...	...	511
Unknown	50,428	4,694	6,297	17,238
Total	2,604,495	3,097,394	3,097,394	3,466,212

Percentage of classes:—

	1845.	1850.	1850.	1855.
United States	84·731	78·672	78·753	72·903
Foreign countries	13·333	21·177	21·043	26·585
Unknown	1·935	·151	·203	0·512

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Migrations.

The published results of the census of 1850 and 1855 confirm the well-known fact that the Americans are migratory in their character, and that the tendency of their migration is westward. In 1850 the number of persons born in this state, but then residing in other states, was 547,218; and the number of those born in other states, but then residing in this state, was 288,100; showing an excess of 259,119 given to other states. The census of 1855 plainly shows that a very large proportion of the inhabitants of the western counties were born in the eastern counties.

Origin of the foreign born.

The following table shows the respective numbers of the population, on the 1st June 1855, born in foreign countries (having over 100 emigrants in the state), and the percentage of the same in the total population:—

Countries.	Number.	Per cent.	Countries.	Number.	Per cent.
Ireland	469,753	13·549	Sweden	1,472	0·042
Germany	218,997	6·314	Italy	1,231	0·036
England	102,286	2·949	Austria	1,197	0·034
Canada	47,842	1·379	New Brunswick	766	0·022
Scotland	27,523	0·794	Denmark	583	0·017
France	18,366	0·529	Spain	570	0·017
Wales	8,557	0·246	Norway	537	0·016
Prussia	6,352	0·183	Belgium	454	0·013
Holland	4,214	0·124	Newfoundland	398	0·011
Switzerland	3,948	0·114	South America	296	0·008
Poland	1,880	0·054	Portugal	291	0·008
West Indies	1,846	0·053	Russia	256	0·007
Nova Scotia	1,602	0·046	Mexico	119	0·003

Census of electors.

In 1821, by a provision of the state constitution as then revised and adopted, the elective franchise was extended to all white male citizens, of the age of twenty-one years, who paid taxes or performed military duty, or who were by law exempt from taxes or military service. In 1826 the constitution was amended by entirely abolishing the property qualification of white voters by a popular vote of 127,077 for, to 3215 against it. Since 1821 the state census period has been decennial, commencing with 1825. Its successive returns of the total population, and of the number of voters and aliens, have been as follows:—

Years.	Total Population.	Total number of Voters.	Total number of Aliens.	Percentage of Pop. Voters.	Percentage of Pop. Aliens.
1825	1,616,458	296,132	40,430	18·32	2·50
1835	2,174,517	422,034	82,319	19·41	3·79
1845	2,604,495	539,379	153,717	20·32	5·89
1855	3,466,212	652,322	632,746	18·01	18·54

Persons of colour.

The constitution of 1821 provided that no man of colour should vote unless possessed of a freehold worth L.52, above all incumbrances, and for three years a citizen, &c.; also, that no person of colour should be taxed unless possessed of said real estate. In the adoption of the constitution of 1846, this provision was retained by a special vote of

[1] The two tables for 1850 are both derived from the official United States census. Their discrepancies are owing to the circumstance that the tables from which these totals were taken were prepared for different purposes, in different ways, and at different times, involving the examination of the names of many millions of persons, and easily giving opportunity for some errors. The first is perhaps the more correct. It is taken from Tables XL. and XLVII. of the *Compendium*, 8vo, and is composed thus:—

Nativities.	Whites.	Free Coloured.	Total.
Born in the State	2,092,076	37,575	2,129,651
Born out of the State, and in the United States	296,754	10,366	307,120
Born in foreign countries	655,224	705	655,929
Unknown	4,271	423	4,694
Aggregate	3,048,325	49,069	3,097,394

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114,900 for, to 3901 against retaining it. The returns of this class have been as follows :—

Coloured persons.	1825.	1835.	1845.	1855.
Not taxed	38,770	42,836	42,321	35,956
Taxed	931	934	2,025	9,330
Voters	298	578	1,001	...

Growth of the cities.

One of the most prominent indications of the recent enumerations is the tendency of the population to centralize in cities and large towns, and apparently at the expense of the rural districts. These changes, however, inevitably result from the greater changes in the general condition of the state and the whole Union. The increase of the facilities of intercommunication has concentrated the trades that they may take advantage of the division of labour. The unlimited field of enterprise offered in manufactures, trade, and commerce, has caused a remarkable growth of cities and towns along the lines and at the centres of the great routes of transportation and travel; and these localities have also received the greater share of the foreign immigration. In 1855 the eight chief cities contained nearly one-third of the whole population of the state. The following table shows their growth :—

Cities.	1830.	1835.	1840.	1845.	1850.	1855.
New York	197,112	268,089	312,710	371,223	515,547	629,810
Brooklyn	17,014	27,854	42,622	72,769	131,357	205,250
Buffalo	8,668	19,715	18,213	29,773	42,261	74,214
Albany	24,209	28,109	33,721	42,139	50,763	57,333
Rochester	9,207	14,404	20,191	26,965	36,403	43,877
Troy	11,556	16,959	19,334	21,709	28,785	33,269
Syracuse	(Incorporated as a city in 1848.)				22,271	25,107
Utica	8,323	10,183	12,782	12,190	17,565	22,169

In 1855 there were twenty-eight townships, with an aggregate population ranging from 5000 to 14,000, which contained one or more flourishing villages; and fifty-four other townships, with a population ranging from 4000 to 6500, with villages, &c.

The rural districts.

In the western and other agricultural sections of the state, the increase of population has been checked by the extensive emigration therefrom to the western states and territories. This emigration has drawn off a considerable share of the best class of the native population. However, it should be considered that, in many sections, agriculture itself requires less manual labour than formerly. The well provided farmer of the present day has his machines for sowing, hoeing, reaping, and threshing, and other improved implements of agriculture.

Occupations of the people.

The employments of the male population over fifteen years of age were thus summed up in the census of 1850:—

Occupations of the People.	Numbers.
Agriculture	313,980
Manufactures, mechanic arts, mining, trade, and commerce	312,697
Labour not agricultural	196,613
Sea and river navigation	23,243
Law, medicine, and divinity	14,258
Other pursuits requiring education	11,104
Government civil service	4,985
Army	1,462
Domestic servants	6,324
Other occupations	3,628
Total	888,294

Owing to the absence of uniformity in the schedules on this subject in the several enumerations, there are no reliable data for comparing the number of persons in the various occupations at different periods.

Productive industry.

New York stands unrivalled among the states of the Union in most of the great branches of national industry. In some few particulars it is surpassed by some states, which have greater natural advantages for the prosecution of those branches,—as Maine, in making lumber and building vessels; Pennsylvania, in raising coal and producing iron; and Massachusetts, in manufacturing cotton and woollen goods, and in prosecuting the coast fisheries. But, taken altogether, the industrial pursuits in New York are more varied and more valuable in their results than those of any other state.

New York State.

Agriculture employs the greater part of the population, exclusive of the inhabitants of the cities and large villages. Great efforts have been made, especially by agricultural societies, to introduce everywhere the best modes of culture, and with much success. Improvements of this class have been particularly made in the vicinity of the city of New York; although in that section this result has been directly owing to the great demands of the populous city. For example, the western part of Long Island has soil that is naturally of moderate fertility; but it has been greatly improved, and it is now noted for its market produce.

Agriculture.

Comparison of some of the Returns in 1850 *and* 1855.

In State of New York.	1850.	1855.
Number of farms, &c.	170,621	231,740
Acres of improved land	12,408,964	13,657,491
Acres of unimproved land	6,710,120[1]	13,100,693
Cash value of farms	L.115,530,545	L.166,532,362
Cash value of implements	4,601,021	5,609,892
Cash value of stock	15,327,183	21,620,007

In 1850, average number of acres in the farms, 113; average value of same, L.675; average value of farming implements and machinery, L.25. According to the census of 1850 (in which the returns of products are for the year ending 1st June 1850) New York ranked as first of the states in its aggregate production of oats (26,552,814 bush. out of 146,584,179 in the whole Union), of buckwheat (3,183,955 out of 8,956,812), of barley (3,585,059 out of 5,167,015), of Irish potatoes (15,398,368 out of 65,797,896), of peas and beans, of market garden products, of orchard products, and of hay, maple, sugar, honey, and hops. The wheat crop was 13,121,498 bush., or 13 per cent. of the whole United States' crop, and ranking as the third state in this respect; that of Indian corn was larger, amounting to 17,858,400 bush., though only 3 per cent. of the United States' crop. It also ranked as first of the states in the amount of its live stock (valued at L.15,325,099 out of L.113,370,936 in the whole Union), in the value of animals slaughtered, and in its products of butter and cheese. Its product of wool was about one-fifth of all in the Union, greatly exceeding that of every other state, excepting Ohio, which was a trifle larger.

Manufactures.

In manufactures New York is very extensively engaged. Its aggregate productions of this class of industry in 1850 not only exceeded the corresponding product of any other state, but amounted to nearly one-fourth of all manufactures produced in the United States.

Statement of Establishments in 1850, *each producing to the amount of* L.104, *or upwards, yearly.*

Classes.	No.	Capital.	Value of Raw Material.	Persons Employed.	Annual Product.
Cotton	86	L.870,189	L.413,740	6,320	L.748,326
Woollen	249	929,032	799,618	6,674	1,464,706
Pig iron	18	126,040	66,878	505	124,564
Iron-casting	323	963,013	499,738	5,925	1,233,742
Wrought iron	81	389,924	480,297	2,130	783,068
Distilling, &c.	189	539,726	...	1,676	...
Tanning	942	1,046,901	1,263,584	4,945	204,298
Salt	192	170,820	131,654	873	207,979
Total	23,553	L.20,813,414	L.28,053,260	199,349	L.49,499,421

Per cent. profit of the total, 53·86; total females employed

[1] This return of unimproved land is of that *attached to farms*.

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(included in the above) 51,612—in cotton works 3668, woollen 2412, tanning 31; total annual wages of all persons employed L.8,360,623. From the census of 1850 it appears that of the classes of manufactures specifically mentioned New York then ranked as first of the states only in the manufactures of iron-casting, those of tanneries, and of salt, beer, and ardent spirits; indicating that its products, aside from the great classes, were of many kinds. It also appears that, in distilleries and breweries, New York employed more capital than any other state (amounting to L.538,726 out of L.1,772,409 in the whole Union); that its product of beer was about four-sevenths, of rum about two-fifths, and of whisky and high wines about two-ninths of all made in the Union. The census of 1855 returned the following statements:—

Total number of establishments		24,833
Establishments using water-power		7,551
Establishments using steam-power		2,444
Persons Employed.	Men 155,159	
	Women 37,771	
	Boys under 18 years 15,736	
	Girls under 18 years. 6,233	214,899
Capital invested in real estate		L.14,818,832
Capital invested in tools and machinery		7,337,406
Cash value of raw materials used		37,165,478
Cash value of manufactured articles		66,128,815

Mining.

The products from mining, so far as reported in 1850, are included in the preceding total of the manufactures. The localities in which this branch of industry is prosecuted are referred to in the previous descriptions of the geology and mineralogy of the state. The census of 1840 reported that 1898 persons were then employed in mining.

Lumber business.

The lumber business of this state is a source of much wealth. The forests about the Sasquehanna and Delaware furnish large quantities of pine for the Philadelphia and Baltimore markets. Albany is noted as one of the greatest markets for lumber in the world, though the greater part of it is not obtained from New York, but from Canada, Michigan, and Ohio.

Fisheries.

The interest of New York in the coast fisheries is important, but there are no official or reliable returns on this subject. In the deep-sea fisheries the state is not largely engaged, and less so now than formerly. The number of vessels in the whale fishery, January 1, 1856, was 31, with aggregate tonnage of 10,493 tons, showing a great decrease from former times.

Building of vessels.

The building of vessels is very extensively prosecuted. The amount of tonnage built within this state annually, during the last four years, has uniformly averaged one-fifth of the whole built in the Union. Nearly all of the great American steam-ships have been built in New York city.

Tonnage owned in New York.

The amount of tonnage owned in this state is proportionably less than the commerce, because many vessels which are employed in its carrying-trade are built, owned, and registered, or enrolled in other states. New York, however, owns two-sevenths of the total tonnage, and one-third of the steam tonnage of the whole United States.

Statement of 30th June 1856.

	New York.	United States.
Total tonnage	1,508,810	4,871,652
Registered steam tonnage	68,777	89,715
Enrolled steam tonnage	155,738	583,362
Total steam tonnage	224,515	673,077

Tonnage of the several Districts in 1856.

New York	1,328,036	Cape Vincent	6,130
Sag Harbour	7,219	Sackett's Harbour	1,571
Greenport	10,238	Oswego	38,888
Cold Spring	1,393	Genesee	4,012
Champlain	11,249	Niagara	566
Oswegatchie	9,572	Buffalo Creek	89,929

Total tonnage owned in the state, 1,508,810; consisting of 734,283 enrolled and licensed, and 774,526 registered.

New York State.

Internal improvements.

The internal improvements of New York are remarkable for their extent and cost, and have most beneficially influenced the prosperity of the state and of the Union. Most of the canals were constructed, and are now owned by the state, and these have an aggregate length of about 800 miles. All the railroads have been formed by incorporated companies, and without the aid of the state, excepting its subscription of L.625,000 to the New York and Erie Railroad. In the interior, especially in the vicinity of large towns, there are many excellent plank-roads, which have probably cost, in the aggregate, at least L.1,000,000. The state's receipts from the canals have of late years varied between L.540,000 and L.625,000 annually; and about one-third of this is expended for the care, repairs, &c., of the canals. The Erie Canal was constructed during 1817-25, 364 miles long and 40 feet wide, at a cost of L.1,488,286; at various periods sections of it have been enlarged, and this work of improvement is still in progress. The Delaware and Hudson Canal was built, and is owned by an incorporated company; 83 miles of its length is within New York. In 1832 the first two lines of railroad were opened,—viz., from Albany to Schenectady 15 miles, and from the latter place to Saratoga Springs. Statistics (September 30, 1855) of railroads in New York:—Length of track laid, 2611½ miles; length of double track, including sidings, 912¼ miles; total cost of road, equipment, and other expenditures, L.26,851,679; total amount of funded and floating debt, L.16,276,209; capital stock paid in, L.14,404,560; gross receipts in fiscal year 1855, L.4,492,224; do. expenses, L.2,520,448. Length of main line of Erie Railroad,—New York city to Dunkirk, 461 miles; New York Central Railroad, Albany to Buffalo, 298 miles; Hudson River Railroad, New York to Albany, 144 miles.

Domestic and coasting trade.

The total amount of the domestic and coasting trade of this state is not known with any exactness; but this, undoubtedly, is in a ratio corresponding to the extent of its canals and railroads, and the amount of its foreign commerce, as compared with other states.

Foreign commerce.

The foreign commerce of New York comprises about two-fifths of the exports of all the United States, and somewhat more than three-fifths of the imports,—thus averaging more than half the foreign commerce of the nation.

The following table is made up from the returns of the collection districts for fiscal year 1856:—

Collection Districts.	Exports.		Imports.
	Domestic.	Foreign.	Total.
New York	L.20,573,660	L.1,270,538	L.40,759,478
Champlain	490,578	242,499	358,000
Oswegatchie	161,374	154,095	376,832
Cape Vincent	138,718	62,218	330,691
Sackett's Harbour	169	...	3,770
Oswego	997,445	142,987	1,108,595
Genesee	157,896	...	232,787
Niagara	182,266	40,562	219,943
Buffalo Creek	180,967	16,845	393,171
Total in 1852	15,425,535	2,800,387	27,568,600
Total in 1854	21,989,942	3,538,101	40,714,148
Total in 1856	22,885,102	1,929,785	43,783,425

Education.

Soon after the organization of the state government, provision was made for an efficient system of public education. Every town is divided into a suitable number of districts, and in each is a school maintained at the public expense. Statistics of the year 1855:—

School districts in which school was kept on an average eight months in the year, *reported*	11,883
Teachers employed (males, 10,117; females 14,019), do.	24,136
Children in state between 4 and 21 years, do.	1,207,214
Attendance in the common schools, do.	876,603
Attendance in private unincorporated schools, do.	45,362
Attendance in academies, do.	29,967

New York State.

Aggregate attendance, as above 951,932
Aggregate expenditures for common schools L.735,817

It may be justly concluded that there is comparatively only a small proportion of the children and youth in the state who do not spend a portion of their time in school.

State Funds for Education.	Capital.	Income 1856.
Common school fund	L.519,146	L.32,736
Literature fund	56,132	3,536
United States deposit fund.....	836,357	53,519

Eighteen collegiate institutions, in the census of 1850, were reported to have 174 teachers, 2673 pupils, and an annual income of L.30,864; and 883 academies, &c., were reported to have 3130 teachers, 49,262 pupils, and annual income of L.168,817.

Public libraries.

Libraries other than private in the State in 1850.

Libraries.	Number.	Volumes.
Public	43	197,229
School	10,802	1,388,729
College	25	138,870
State school	137	33,294
Church	6	2,698
Aggregate of libraries reported,	11,013	1,760,820

The Press.

In 1810 there were 66 newspapers, with circulation of 4,139,200; in 1828, 161; and, in 1834, 267 issues; of which 21 were dailies. The returns of subsequent periods are as follows:—

The Press.	Number in 1840.	1850. Number.	1850. Copies Yearly.	Number in 1855.
Dailies	34	51	63,928,685	73
Tri-Weeklies ... / Semi-Weeklies..	13	8	776,100	13
		13	3,116,360	16
Weeklies	198	308	39,205,920	411
Monthlies, &c.....	57	48	8,358,408	157
Total.....	302	428	115,385,473	670

In 1855, number whose circulation was reported... 540
Copies printed per annum of those reported.....193,294,621
Estimated copies per annum of all classes.....241,749,902

Churches.

The following table presents the statistics of the principal religious denominations, according to the census of 1855, preceded by the total, which embraces over forty sects. These returns are of those religious societies that have each a regular chapel of their own, not including those that worship in schoolhouses and places of secular use:—

Denominations.	Chapels.	Value of Property.	Usual Attendance.	Church Members.
Baptists, four sects.....	882	L. 658,233	143,465	89,713
Congregational.....	301	300,873	56,637	25,946
Evangelical Lutheran.	100	81,281	20,834	13,964
Friends	134	86,533	9,985	5,340
Methodists, nine sects.....	1580	958,607	250,995	140,196
Presbyterians, five sects...	710	1,239,137	163,054	92,712
Protestant, Episcopal.....	346	1,396,626	78,698	32,978
Reformed Protest. Dutch	260	628,146	70,093	30,197
Roman Catholic	291	798,184	272,084	242,225
Union Bethel and Free ...	152	46,834	17,415	7,923
Universalists	133	143,528	18,064	4,570
The total.....	5077	L.6,558,547	1,124,211	702,384

Average value of churches, L.1290; average accommodation, 421; average number of inhabitants to each church, 683. Percentage of accommodation to total population, 61·73; of attendance do., 32·41; of membership do., 20·23.

Pauperism, &c.

By census of 1825 the percentage of paupers to total population was 0·34; do. 1835, 0·31; do. 1845, 0·32. The census of 1855 made no report on this subject. It is known, however, by the annual reports of the secretary of state, that pauperism has, since 1845, been much increased, though in no greater ratio than the foreign immigration, to which it is in a very large degree attributable.

New York City.

During the year 1855 there were convicted in the courts of record of the state 1842 persons, as follows:—Of offences against the person, 397 (383 males and 14 females); offences against property with violence, 278 (275 males and 3 females); offences without violence, 586 (507 males and 79 females); offences against the currency, 37 (36 males and 1 female); all other offences, 544 (513 males and 31 females). In all the courts there were 6744 convictions, and of these 5076 were of foreigners.

Crime.

There are three state prisons, in which for the 8 years 1847–55, the average yearly number of prisoners was about 1700; and the average yearly increase was 86. Number on 1st December 1855, 1901 (1679 whites and 222 blacks); and of these 92 were white females, and 14 black females.

State prisons.

The state has two establishments for the reformation of juvenile offenders. The older one, at Randall's Island, city of New York, was opened in 1825; and, up to the close of 1856, had received 6880 children and youth, of whom it is believed that 70 per cent. were there reformed.

Houses of refuge.

The state maintains numerous public institutions for those unfortunate by nature or calamity. These are very extensive, and conducted according to the best practice known in similar establishments. The chief of these are —the lunatic asylum at Utica; institution for the deaf-and-dumb at New York; institution for the blind at New York; and the asylum for idiots at Syracuse. At New York also, partly sustained by the state, are the City Hospital, Bloomingdale Asylum for the insane; emigrant hospitals; institutions for seamen; dispensaries, &c. (F. H.)

Public institutions.

NEW YORK, city and port of entry, New York county, state of New York, lies at the head of New York Bay, and at the confluence of the Hudson River and the strait called East River, which connects Long Island Sound through New York Bay with the Atlantic Ocean. It is the commercial metropolis of the state of New York, and the greatest emporium in the New World. In general importance it surpasses all other great cities of the world, excepting London and Paris. Its area comprises (the city and county having the same limits) the whole of Manhattan or New York Island, and several small islands immediately adjacent. The separation of the former from the mainland is caused by the water-course called Harlem River, connecting the Hudson and East Rivers; but this is, in fact, of little account; for, although the stream is, or might be, of considerable service in navigation, it is crossed by bridges and the Croton Aqueduct. The extreme length of New York Island is about 13½ miles; its width through the greater part of its length is about 2 miles; but at each extremity it decreases irregularly; and its area is about 14,000 acres, or 22 square miles. Lat. of the City Hall 40. 42. 43. N., Long. of do. from Greenwich 74. 0. 3. W.

Harbour, bay, and rivers.

New York enjoys from nature almost every advantage that could be desired to build up a great emporium. It extends between two rivers, each of which is navigable for the largest vessels; and the harbour, below their confluence, might contain the navies of all nations. The width of the Hudson River is quite uniform, and is somewhat more than a mile; while that of the East River varies, being, in some narrow localities, not more than two-fifths of a mile, though generally much greater. The harbour or inner bay is of irregular elliptical form, about 8 miles long and 25 miles in periphery. This is not only one of the best but one of the most beautiful harbours in the world. Its southern part is surrounded with small settlements, connected by elegant villas and their gardens. Toward its northern part the number of vessels at anchor increases; and beyond these is the dense forest of masts, bearing the flags of all nations, crowded around the wharves of the great city and its suburbs. In it are three islands ceded to the national go-

New York City.

vernment, and fortified for the defence of the city. By the strait called "the Narrows," 7 miles from the lower part of the city, and which is, for the space of a mile, about 1 mile wide, with extreme depth of 86 feet, it communicates with the outer harbour, or bay proper, which extends thence to Sandy Hook Light, 18 miles from the city, and opens directly out into the ocean, forming one of the best roadsteads on the Atlantic coast. On the bar, at Sandy Hook the depth of water in the old channel is 21 feet at low tide, and 27 or 28 feet at high tide; but, in the New or Gedney's Channel, it is 32 at low tide, and 38 or 39 at high tide. The channel inside varies from 35 to 72 feet. The rise of the tide is nearly 7 feet. The depth of water at the wharves is sufficient for the vessels which they respectively accommodate, and increases rapidly outwards. The currents in the rivers and bay are very strong, keeping these waters open when the rivers and bays much farther south are frozen up. In very severe winters the East River is obstructed for a short time by ice; which, in a few cases, has collected so as to form a solid mass.

Defences.

The harbour has for a long period been well provided with defences, and these are being steadily augmented by the general government. The principal works are at the Narrows, which is the most important and most readily accessible avenue of approach. On the Long Island side, or shore of the channel, are Fort Hamilton and Fort Lafayette. On the Staten Island side, or shore of the channel, are batteries Hudson and Morton, Fort Richmond (in 1857 not completed), and Old Fort Tompkins. Quite near the lower point of the city there are fortifications on three islands,—Governor's, Bedlow's, and Ellis's,—and to these may be added Castle Clinton, which is now entirely dismantled, but occupies a good position, and might again be put in serviceable condition. The passage by the East River from Long Island Sound is defended by Fort Schuyler, a powerful work, situated at a narrow pass in the river, about 17 miles from the lower part of the city. Since 1854 there has been in construction a monster iron steamer, or steam battery, designed for use in the waters of the bay from Sandy Hook upwards, and intended to be, in fact, a moveable fort of great efficiency. In 1857 Congress provided for the commencement of a fort opposite Fort Schuyler; for the erection of another on the site of old Fort Tompkins; for the repairs of those already established; and for extensive fortifications at Sandy Hook.

Surface.

The island was originally much diversified; and, in its upper portion, where least peopled, it still retains somewhat of its original character. The elevated rocky portions subsequently mentioned, vary from 70 to 130 feet above tide water—the valleys being often deep, and the hills precipitous. With the increase of population improvements have been made according to a uniform system, in laying out avenues and streets, levelling them, providing sewerage, &c. The island is traversed centrally throughout its lower part by a ridge, on each side of which the ground slopes gently to the water. There is also a line of elevation along the western side of the island in its upper part, from which the ground descends to the Hudson and the East River. A considerable portion of the lower part of the city, particularly that near the rivers, is artificial ground. The Battery, a public park at the southern extremity, was made upon a low ledge of rocks, much beyond the original water-line, at first of 10 acres; but since 1854 it has been extended to 17 acres.

Geological formation.

The island lies upon the upturned edge of the primitive range which extends through Westchester county and the New England States into Canada. The basis rock is gneiss, except for about 1 mile at the northern extremity, which is limestone, granular and primitive, and considerably quarried. The middle and northern portions are, or were, rough and broken, from the almost constant outcropping of the rock. The rock begins to makes its appearance in the neighbourhood of Thirtieth Street, and thence extends northward to Manhattanville. In many places it occupies large patches. On the west side of the city, not far from the Hudson River, between Fiftieth and Sixtieth Streets, and in some other parts, streets were cut through it. The lower portion is everywhere covered with alluvial and diluvial deposits, and is comparatively level. The soil is a sandy alluvion, and less fertile than in many other parts of the state.

New York City.

Events in the annals of the city.

The history of the city is directly divided into three periods, during which it has belonged to the three governments,—Holland from 1609 to 1664; Great Britain from 1664 to 1783; and the state of New York since 1783. The most prominent events in each period are thus stated:—

Dutch period.—1609, September 3, Hendrick Hudson entered New York Bay; 1613, the settlement of New Amsterdam was commenced; 1621, the Dutch West India Company commenced operations; 1626, the island was purchased of the Indians; 1652, New Amsterdam was incorporated, and the government passed from the West India Company into the hands of two burgomasters and five assistants, called schepens, and one schout or sheriff; 1664, September 9, the English took the province.

English period.—1664, name changed to New York; 1673, July, retaken by the Dutch and called New Orange, and held by them until ensuing year (treaty of 9th February 1674); 1686, James II. abolished the representative system, &c.; 1689, Leisler insurrection; 1690, a colonial congress assembled here; 1696, city lighted by ordinance; 1711, slave-market established in Wall Street; 1720, two per cent. laid on European imports; 1725, *New York Gazette* appeared; 1730, enlarged charter granted by Governor Montgomerie; 1732, stage routes established to Boston and Philadelphia, travelled once a month; 1741-2, "Negro plot" and yellow fever; 1765, a colonial congress assembled here; 1776–83, Revolution; 1776, September 21, a few days after the city had fallen into the hands of the British, a conflagration, destroying from one-eighth to one-fourth of the whole city; 1783, November 25, evacuation by British army.

American period.—1789, April 30, Washington inaugurated first president of the United States at Federal Hall, on site of present custom-house; 1798, 2086 deaths by yellow fever, which returned in 1803, 1805, and 1822; 1807, Fulton's steamboat on Hudson River; 1811, great fire; 1812, war with Great Britain, which suspended commerce; 1126, Erie Canal completed and great celebration; 1832, Asiatic cholera, 4360 deaths; 1835, December 16, 17, conflagration of 648 buildings, loss L.5,200,000; 1837, commercial revulsion; 1842, October 14, celebration of completion of Croton Aqueduct; 1845, conflagration of 546 buildings, loss L.1,250,000; 1849, cholera; 1850, Collins' steamers to Liverpool; 1851, May, Erie Railroad completed to Dunkirk; 1852, avenue railroads; 1853, World's Fair at Crystal Palace; 1854–5 (winter of), temporary depression of business, and suffering among the poorer classes; 1857, May 1, new city charter partially carried into effect; June 16, culmination of the riot resulting from opposition to the reorganization of the police department, followed through the summer by disturbances about municipal affairs; September and October, a terrible financial panic, which increased daily to 14th October, when the banks suspended specie payment; 1858, January 4, new city charter carried into full effect, with installation of new officers.

The foregoing enumeration of the principal occurrences in the annals of the city does not constitute or comprehend a correct outline of its real history. For a correct understanding of this, we must compare the progress of the city with the outline history of the domestic and foreign commerce of the United States; and by so doing it is readily

New York City.

apparent that the remarkable prosperity of the former has resulted from the general prosperity of the latter.

Growth of New York the result of commerce.

Commercial interests originated the settlement of New York, developed its rapid growth, have always directly influenced its changes of fortune, and are now the main support of its greatness. With the fluctuations of the course of events, in regard to general commerce, there has always been a corresponding change in the ratio of increase of the population of the city and its general prosperity. After the close of the Revolution, an activity in business was everywhere apparent; and the citizens, by their persevering industry, were ultimately enabled not only to materially advance their own private interests, but also to promote the prosperity of the community at large. During the ten years from 1790 to 1800, the population of the city increased from 33,131 to 60,489, or at a ratio of 82·16 per cent. During this period the old world, involved in wars, was making constant demand upon the productiveness and industry of the new world. In the latter, the produce of New York and the Western States was pressing to the Atlantic, whence the shipping of the port of New York carried it abroad, returning again with goods for distribution, both in its own and neighbouring markets. Thus the business of the city increased wonderfully, and its attendant advantages drew thither capital and men to participate in the profits from the large investments there made. During the next decade, 1800 to 1810, there was a falling off of the ratio of increase of both population and wealth, and business enterprise was greatly depressed. Though the increase of population during this period was at a ratio of 59⅓ per cent., viz., from 60,489 in 1800 to 96,783 in 1810, the increase in wealth was but 8 per cent.: viz., from L.5,101,323 to L.5,407,572. In the first half of the succeeding 10 years, 1810-20, the foreign commerce of the city was entirely suspended for 3 years by the war of 1812–14 with Great Britain; after which, from 1815 to 1820, it again revived, and greatly promoted the prosperity of the city and nation. During this period, 1810–20, the increase in valuation was from L.5,407,572 to L.14,485,568, or 163 per cent.; while the increase in population was from 96,373 to 123,706, or only 28½ per cent.; which ratio is less than that of any other decade, and clearly illustrates the connection of the city's growth with commerce, since, during this same period, the increase of the population of the state was more rapid than ever before. From 1820 commerce steadily increased until 1825, in which year it reached a climax that was not again attained until 1831. In 1826 the completion of the Erie Canal opened a new avenue for trade and commerce, and assisted in the formation of the great speculations which soon characterized the financial career of the city. The reaction that followed this unnatural prosperity for a time prostrated all branches of business, and most seriously affected the commercial interests of the city. Since its recovery from that reverse of fortune, its commercial prosperity has, for the most part, been steadily augmenting, though of course somewhat affected by the changes in the tariffs of the national government, and by the changing relations of the nations with which it has had intercourse.

Progress of population.

Progress of Population of the City Proper.

Year	Population.	Year.	Population.
1673	2,500	1814	95,519
1698	4,937	1816	100,619
1731	8,628	1820	123,706
1756	10,381	1825	166,086
1773	21,876	1830	202,589
1786	23,614	1835	268,089
1790	33,131	1840	312,710
1800	60,489	1845	371,223
1805	75,770	1850	512,547
1808	83,530	1855	629,810
1810	96,373		

The census of 1855 (June and July), is known to have been very defectively taken, and it is highly probable that a correct enumeration would have shown a permanent population of above 700,000. The population of the immediate suburbs should also be considered in this account, since these are, in fact, parts of the metropolis. New York City.

Suburbs and their growth.

On the East River side is the city of Brooklyn, which, since 1854, has comprised the former cities of Brooklyn and Williamsburg, and the town of Bushwick. The following table states the progress of population from 1840, in each of its divisions and in the whole of King's county, which consists of the city and several towns:—

Years.	Consolidated City of Brooklyn.				King's County. Total.
	Brooklyn.	Williamsburg.	Bushwick.	Total.	
1840.....	36,233	5,094	1,295	42,622	47,613
1845.....	59,574	11,338	1,857	72,769	78,691
1850.....	96,838	30,780	3,739	131,357	138,882
1855.....	148,774	48,367	8,109	205,250	216,355

On the New Jersey side of the Hudson, opposite the lower part of the city, are Jersey city and Hoboken. The population of the former, in its present area, was 11,473, and in 1855, 21,715; that of the latter was, in 1850, 2668, and in 1855, 5842; and this growth was but a continuance of previous duplication. Newark, the largest city in the state of New Jersey, situated 8 miles west of Jersey city, in 1830 had 10,953 inhabitants; in 1840, 17,290; in 1850, 38,894; and in 1855, 53,440; and this growth was, in great part, owing to that of New York, since the greater part of the business consists in producing manufactures for the New York market. The manufacturing city of Paterson, 16 miles from Jersey city, had 7596 inhabitants in 1840, 11,334 in 1850, and 23,960 in 1855; and its business likewise centres in New York.

Origin of Population of New York in 1845–50–55.

Origin of Population.	1845.	1850.	1855.
Born in the United States.....	236,567	277,752	303,721
Born in foreign countries.....	128,492	235,733	322,366
Born at sea.....	...	...	103
Unknown.....	6,164	2,062	3,620
Total population.....	371,223	515,547	629,810

Origin of those Born in the United States.

Origin of Population.	1845.	1850.	1855.
The state of New York.....	194,916	234,843	262,156
The New England States (6).....	16,079	17,543	17,976
Other States of the Union.....	25,572	25,366	23,589
Total United States.....	236,567	277,752	303,721

Summary of those Born in Foreign Countries.

	1850.	1855.
England } Wales... }	23,671	22,713
		935
Scotland	7,660	8,487
Ireland	133,730	175,735
Germany	55,476	95,986
Prussia	665	1,586
Austria	109	331
Italy	708	968
Spain	303	343
France	4,990	6,321
Various other countries	8,421	8,961
Total	235,733	322,366

The free coloured.

In 1850 the population comprised 13,815 free coloured persons, and we have the following statistics concerning them:—

New York City.

Items of Returns.		Mulattoes.	Blacks.	Total.
Males		1,330	4,765	6,098
Females		1,736	5,984	7,717
Number of families		663	2,326	2,989
Number of dwellings		211	721	932
Born in state of New York		1,887	6,469	8,356
... ... New Jersey		246	1,234	1,480
... ... Virginia		166	712	878
... ... Pennsylvania		169	513	682
... ... Maryland		170	580	750
Occupations of males over 15 years.	Labourers	187	957	1,144
	Servants	196	612	808
	Barbers	42	80	122
	Coachmen	11	96	107
	Cook	17	78	95

Sixty of this class were engaged in pursuits requiring education, of which one-third were Mulattoes.

Civil condition.

The census of 1855 is the first that affords data for comparison of the number of single, married, and widowed in the population. In the city the percentages of these classes were—single, 60·78; married, 34·41; widowers, 1·04; and widows, 3·63.

Voters and aliens.

The number and percentages of aliens and voters since 1821 in the city have been as follows:—

Census.	Total Number.		Percentage to Pop.	
Years.	Vo ers.	Aliens.	Voters.	Aliens.
1825	18,283	18,826	11·10	11·33
1835	43,091	27,669	15·95	10·24
1845	63,927	60,946	17·22	16·14
1855	88,877	232,678	14·11	36·93

Adults unable to read and write.

Of adults (above 20 years) unable to read and write there were in the city in 1840, 7775 whites. The same class in 1850 (also above 20 years) consisted of 17,140 whites, and 1667 coloured; or a total of 18,807—of whom 2358 were native, and 16,449 foreign born. In 1855 the total number, white and free coloured, above 21 years, was 25,858, originating as follows:—

Countries.	Males.	Females.	Countries.	Males.	Females.
Ireland	6,383	14,995	Switzerland	3	6
England	97	162	Other European Countries	260	223
Scotland	20	41			
Germany	597	856	Canada	25	8
France	43	56	United States	1,108	955

Families and dwellings.

Returns of 1850 *and* 1855 *on Families and Dwellings.*

Statements.	Dwellings.		Families.	
	1850.	1855.	1850.	1855.
Number	37,677	42,668	93,608	126,558
Persons in each	13·60	14·79	5·47	4·97

In 1855 the total value of dwellings, including the value of their lots, was reported at L.56,975,391, being an average of L.1333.

Owners of land.

The number of all classes reported in 1855 as holding land by deed, contract, or perpetual lease, was 14,784, or 2·34 per cent. of the whole population. The total value of real and personal estate in the city and county of New York, for the year 1856, was L.106,612,599, of which L.70,935,849 was of real estate.

The valuation, as stated previously, is less than the real value of property assessed. In 1856 the total valuation of the "moneyed or stock corporations deriving an income from their capital" was L.19,648,062, consisting of L.17,363,539 personal estate, and L.2,284,523 real estate; on which the tax for city purposes was L.271,248.

Plan.

The general plan of the city is regular. In the old or southern part, now devoted wholly to business, the principal streets were in part formed according to the shape of the island, and hence its plan is not continuously uniform, although each of its large divisions is by itself comparatively regular. The uniform plan of avenues and streets commences at Houston Street, 1 mile from the City Hall, and 1¾ miles from the Battery. Above this point the island is divided longitudinally by fourteen parallel Avenues. 100 feet wide, which are crossed at right angles by 156 streets, numerically designated, running directly from river to river, and 80 feet wide, excepting sixteen. The latter are 100 feet wide, of which Fourteenth Street is the first that extends entirely across the island. The principal street is Broadway, especially that main portion of it which occupies the central ridge of the island, extending in a straight line, and with uniform breadth of 80 feet, nearly 2¼ miles, from the Battery to Tenth Street (Grace Church). It is mainly occupied by stores, but it also contains the principal hotels and theatres, besides several banks and other prominent structures. Although a very large proportion of the buildings in this street are of costly construction, so that there is not a more splendid business thoroughfare in the world, yet its general aspect is impaired by a remarkable diversity of architecture, for almost every block comprises several fronts of marble, sandstone, and brick. The Bowery is the next most important of the thoroughfares; it is more plainly built, and is traversed by some of the city railroads. Fifth Avenue is the central street of the most elegant and fashionable portion of the city, and is wholly occupied by very costly private residences, which are chiefly constructed of brown sandstone; and several fine churches. Like all other large cities, however, New York has many streets which are lined with cheap, miserable, and densely-peopled tenements, which, with their inmates, afford a sad contrast to the display of wealth and magnificence in other sections. New York City. Principal streets.

Public parks.

Besides the great central park, the city has seventeen public squares and other areas, for the most part of small extent, though varying in size, their aggregate area being 170 acres; they are generally inclosed with handsome iron fences, and ornamented with trees, fountains, &c., affording pleasant promenades. The new central park, designed in 1853, and not yet completed, extends from Fifty-ninth to One Hundred and Sixth Street, between Fifth and Eighth Avenues. It is 2½ miles long by half a mile wide, comprising 776 acres, including the present distributing reservoir (occupying a position nearly central), the ground taken for a new reservoir, and the Arsenal grounds belonging to the state, and valued, as first taken in its unimproved state, at L.1,076,947. Its surface is somewhat uneven, and its natural configuration is used as the basis of the improvements. There are two beautiful parks, each comprising a square, which are private property.

Movement of population.

Owing to the natural shape of the island, to the fact that it was first settled at its southern extremity, and to the eligibility of that section for the extension of trade and commerce, it has resulted that the growth of the city has, with successive years, been manifested by an increase of houses and business buildings in a northward direction. In the southern and business section the number of dwellings has yearly decreased, the old houses being pulled down, and stores or other establishments erected. Therefore in that section the number of inhabitants, instead of increasing or remaining stationary, has rather diminished, and the absolute increase of population has been most apparent in the northern section. In the spring of 1853 the city was quite compactly built from the Battery to Forty-second Street, 4 miles. In that year, and somewhat before, a great impulse was given to the northward movement by the erection of the Crystal Palace; and also by the sale on the part of the city of large tracts of ground in that section. The increase, since 1853, of population in the northern sections has been very great, and in part attributable to the introduction and extension of city railroads.

Styles of building.

The several sections of the city are characterized by considerable uniformity in their respective styles of building. In the upper parts many of the blocks consist of houses

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constructed precisely alike. Building lots are almost everywhere of equal width. In the older streets the buildings are almost wholly of brick, which is now by far the chief building material in all sections; though of late years the use of freestone, marble, granite, and iron, for the front of buildings, has become quite general.

Public edifices.

The City Hall occupies the centre of the park, in the lower part of the city. It is a very large and handsome edifice, built, in combined Ionic and Corinthian orders, of white marble, except its north side, and surmounted by a cupola, which is crowned by a statue of Justice. It was constructed between the years 1803 and 1812, at a cost of L.112,232. It contains 28 apartments, used as the public offices of the mayor and other members of the city government. The principal apartment, called the Governor's Room, contains a fine collection of portraits of men celebrated in the civil, military, and naval history of the country. In the common council-room is the identical chair occupied by Washington when president of the first American Congress, which assembled in this city. In the rear of this edifice is another large building, occupied by the principal courts and some public offices; and east of it is the Hall of Records, in which are preserved all the records and public documents of the city.

The Merchants' Exchange, occupying an entire block, is built of Quincy granite, and cost about L.375,000. Its front has a recessed portico with 18 columns, each of which is a solid block of granite, 38 feet high, 4½ feet in diameter, and weighing over 40 tons. Its central rotunda is elaborately constructed of white marble, and lighted by a very lofty dome, which is in part supported by 8 Corinthian columns of Italian marble, 41 feet high.

The Custom-House (on the site of the old Federal Hall, where General Washington was inaugurated the first president) is built of white marble, in the Doric style, after the model of the Parthenon, with two grand porticos, each having 8 massive columns; its principal hall is circular, surmounted by a dome, supported by 16 Corinthian columns, 30 feet high, beautifully wrought with capitals of the most exquisite workmanship. Its construction occupied seven years (1834–41); and its cost, ground included, was L.248,900.

The Post-Office is not noteworthy for its architecture, though it is so for its history. It was formerly the Middle Dutch Church, and was erected before the Revolution. Much of its interior wood-work and its steeple were brought from Holland during the Revolutionary war; this church, in common with others used by the British, was much injured from its occupation as a prison, hospital, &c. In 1790 it was repaired, and continued to be used for public worship until rented by the United States government for the general post-office of the city.

The Hall of Justice, or city prison, is an extremely massive granite building of Egyptian architecture, and occupies an entire *block*. Its gloomy aspect has obtained for it the general name of "The Tombs." Its front has a recessed portico, supported by 14 huge columns. It is chiefly occupied as a prison, though in part by the criminal courts, and in part as a police station.

The Crystal Palace was erected in 1853 for the World's Fair, or "Exhibition of the Industry of all Nations," on Reservoir Square, 3 miles from the City Hall. Since the close of that exhibition it has been used only at intervals, and then for sundry fairs, exhibitions, and festive assemblages. It has a somewhat octagonal form; each main diameter is 365½ feet long, and the area of its flooring is 173,000 square feet. The dome is 100 feet in diameter, and 123 feet high. Excepting the floors, the building was constructed entirely of iron and glass,—requiring 1800 tons of iron, 55,000 square feet of glass, and 750,000 square feet of timber.

The State Arsenal, 4½ miles from the City Hall, is a large edifice, containing arms and munitions belonging to the state. It was erected in 1848, and is in the Gothic castellated style, presenting a massive and appropriate appearance. New York City.

The City Armoury, or Down-Town Arsenal, is a handsome structure in the Gothic style, two stories high, built of blue stone. It is constructed on the best plan for defence; as, for example, its windows are only 18 inches wide, so that in case of an attack it could be defended with success by fifty men. In January 1855 the citizen soldiery of the city (comprised in the First Division, New York State Militia, in four brigades) consisted of—infantry, 3906; cavalry, 1291; and artillery, 1589: total, 6786.

Hotels.

The hotels of New York are generally very large, and noted for their excellence; while a considerable number cost fully L.200,000, and are remarkable for their splendour. Upon Broadway alone there are about twenty-five, all elegant in their appointments, and severally accommodating from 200 to 800 guests. Prominent among these, as the oldest, and not surpassed in substantial excellence by any of the more recent establishments, is the Astor House, a rare example of popular favour, deservedly secured and long and surely retained. It was erected by John Jacob Astor, at a cost of L.165,000, and opened in May 1836. The building is constructed of Quincy granite, in the most substantial manner, and contains about 400 rooms. The St Nicholas Hotel, opened in 1853, and subsequently much enlarged, now constitutes the most capacious and costly hotel in the world. It is built of white marble and freestone, and is noted for the splendour of its apartments and its general magnificence. The Metropolitan Hotel, built of freestone, and a very imposing and attractive edifice, was opened in September 1852. Of similar character with these three are the Clarendon, Everett, Brevoort, St Germain, and Lafarge. To this list might be added others of nearly equal rank. The United States Hotel, built of marble, at a cost of L.72,000, containing about 250 rooms, was the first of the *mammoth* hotels. Many other hotels are very large, elegant, and well appointed; but their great number precludes particular mention. Hotel-keeping, as practised in New York by the best houses, is brought nearer perfection than in any other city in the world.

City conveyances

Until the summer of 1852 the omnibuses of the city afforded almost the only means of cheap and regular conveyance. Up to that time these were very extensively used by the people, as they yet are, except in certain thoroughfares, where they have been superseded by the railroads. The city cars of the Harlem Railroad commenced running in June 1833, and at the same rate of fare as the stages. In August 1852, notwithstanding the strenuous opposition of thousands against the establishment of railroads through the leading avenues of the city, the Sixth Avenue and the Eighth Avenue lines commenced operation; and in July 1853 the Second Avenue and the Third Avenue lines. These channels of travel are now better patronized than the stages ever were, or ever would have been, had the roads not been formed. On each line the fare is 2½d., without regard to the length of the routes, which vary from 2¾ (Fourth Avenue) to 5¾ miles (Third Avenue). The cars (which are drawn by horses or mules, and are about twice the length of an omnibus) run day and night, at intervals varying from two to thirty minutes, according to the public requirements. Their successful operation has resulted in their establishment in other cities.

Omnibus lines and hacks, &c.

There are thirty lines of omnibuses, having in all about 600 in daily use. The routes of these lines vary in length from three to five miles. The uniform fare is 3d. With these Broadway is often completely blocked from morn till midnight, all efforts to remove or supersede them having proved ineffectual. The number of hacks is not propor-

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tionate to the population of the city, owing mainly to the greater facilities afforded by the more popular conveyances, and somewhat to the extortionate demands of the hackmen, though their rates are duly prescribed by law. By census of 1855, 1741 persons were occupied as drivers; 5838 as carters and draymen; 3052 as porters; and 1004 as boatmen and watermen.

Ferries.

Between New York and its immediate suburbs across the rivers, steam ferry-boats are constantly plying. On the principal ferries these are run throughout the night as well as the day. From the populous part of the city there are, across the East River, fourteen ferries, and across the Hudson four; and from the upper part of the island there are others across each river. On the East River the ferriage is (excepting for the longest routes) 1d.; on the Hudson 1½d. The number of passengers, vehicles, &c., crossing daily is very great. In the morning and towards night the boats are often crowded. To many places near the city steamboats are run, especially in summer, at very low rates of fare.

Manufactures.

In its manufactures, as well as commerce, New York is the first city in America. In 1850 the number of hands employed in manufactures, mining, or the mechanical arts (establishments producing annually to the amount of L.104), was 80,302; capital invested L.6,126,615; product annually L.1,882,958. The branches which are here most extensively prosecuted are those directly developed by the great trade and commerce.

Building of vessels.

Ship-building is carried to a high degree of perfection; and in speed, beauty of model, and internal convenience, the vessels built here are nowhere surpassed.

Table showing the number of vessels of all kinds built in the district of New York, with their aggregate measurement, from 1843 *to* 1857, *compiled from the Treasury Reports:—*

Fiscal Years.	Ships & Barques	Brigs.	Schooners.	Sloops and Canal Boats.	Steamboats.	Total Vessels.	Total Tonnage.
1843	5	2	8	102	5	122	13,179
1844	11	6	16	89	14	136	18,026
1845	18	2	25	130	17	192	26,621
1846	11	3	37	160	23	234	29,465
1847	16	2	43	117	15	193	37,591
1848	26	3	59	200	19	307	57,977
1849	15	7	44	145	17	228	37,933
1850	26	2	42	104	28	202	55,525
1851	23	1	56	81	47	208	77,214
1852	24	2	46	38	43	153	69,054
1853	18	5	66	97	58	244	68,454
1854	40	7	63	81	49	240	93,496
1855	40	5	76	219	41	381	92,697
1856	24	7	35	108	17	191	49,317
1857	28	5	37	73	21	164	43,118

The construction of splendid ocean steamers has, since 1846, formed a distinguishing feature in the business of the New York ship-yards. Of these there have been launched about 120, all of which have fully satisfied, and in fact exceeded, the expectations of their builders; while several have become celebrated throughout the world as superior to all, of every other nation, previously afloat. So great, however, has been the rivalry between American and British ship-builders, that, since 1850, the marine of each nation has been yearly increased with new steamers, constructed to surpass all their predecessors. This rivalry, still continued, promises to furnish both of these countries, and others also, with a vast number of steamers, which will greatly promote their respective interests, and aid in extending civilization over the globe.

Tonnage in steam navigation.

The increase in the amount of the tonnage employed in steam navigation since 1848, and owned in the district, is exhibited in the following table:—

Years.	Registered.		Enrolled & Licensed.		Total.	
	Tons.	95ths.	Tons.	95ths.	Tons.	95ths.
1848	6,523	73	57,705	41	64,229	19
1849	10,642	76	61,175	92	71,818	73
1850	36,148	47	58,967	9	85,115	56
1851	52,392	68	69,148	89	121,541	62
1852	63,860	33	77,063	84	140,924	22
1853	76,851	78	88,311	53	165,163	36
1854	82,607	73	101,487	41	184,095	19
1855	89,105	9	107,692	88	196,798	2
1856	68,777	26	107,820	67	176,597	93
1857	69,051	67	111,526	89	180,578	61

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Total tonnage of the district.

The following statement from the annual reports of the Secretary of the United States Treasury exhibits the registered, the enrolled and licensed, and the total tonnage belonging to the district of New York, in each decennial year from 1825:—

Years.	Registered.		Enrolled & Licensed.		Total.	
	Tons.	95ths.	Tons.	95ths.	Tons.	95ths.
1825	156,728	14	147,756	8	304,484	22
1835	191,626	43	185,071	29	376,697	72
1845	248,717	...	301,642	48	550,359	48
1855	737,509	37	550,725	29	1,288,234	66
1857	802,356	10	575,068	51	1,377,424	61

Coasting trade.

Nearly all of the enrolled and licensed tonnage is employed in the coasting trade; but there are no complete official accounts of this trade. The law exonerates vessels engaged in it from entering or clearing at the custom-house, unless they have foreign goods or distilled spirits on board; and comparatively few vessels which arrive from a domestic port come within this exception. The record of clearances coastwise (as many such vessels take foreign goods or spirits) exceeds the number entered; but even this list is far from including all which are engaged in this trade. The following summary, derived from the custom-house records, is for the calendar years mentioned:—

Years.	Entered Coastwise.		Cleared Coastwise.	
	Vessels.	Tons.	Vessels.	Tons.
1849	1855	424,976	3994	805,589
1851	1768	455,542	4803	1,214,942
1853	1733	507,531	4789	1,310,697
1855	1966	614,045	4563	1,378,889
1856	1669	539,461	4696	1,482,310

The coastwise trade is carried on entirely by American vessels, built and owned within the United States, as foreign vessels are by law prohibited from engaging in it.

Coastwise arrivals.

In addition to the foregoing, we give the following statement of coastwise arrivals for three years, collected from the returns of Mr James Thorne, boarding-officer, United States revenue department, Whitehall:—

Years.	Steamers.	Ships.	Barques	Brigs.	Schooners.	Total.
1855	460	220	208	422	4992	6302
1856	523	150	177	371	4888	6109
1857	521	117	129	304	5026	6097

NOTE.—In the above no sloops are included. These, if added to the many schooners from Virginia and Philadelphia, with wood and coal, which, though consigned here, discharge their cargoes at Brooklyn, Williamsburg, Jersey city, and the adjacent towns on the Hudson, and are not boarded owing to the remoteness of these points for general business, would make the number much greater. The officer estimates the *schooners* that arrive at the above places and are not reported, at eight per day; which he thinks is an estimate rather under than over the actual number. This would give for each year 2920 additional schooners to be added to the coasting trade, making the whole number of coastwise arrivals in 1855, 9222; in 1856, 9029; and in 1857, 9017. In the above statement the steamers arriving from New Orleans, *via* Havana, are included.

The trade of the city with the interior of the Union

New York City.

New York vastly exceeds its foreign commerce; but of this there are no full reports. The available data consist of the accounts of the articles brought to tide-water by the Erie Canal, and the statistics of freight-traffic on the railroads which centre in the city. Of the latter the most important is the Erie Railroad, which bears a relation to the entire southern portion of the state, and northern portion of Pennsylvania, very similar to that sustained by the Erie Canal to the northern part of the state. The eleven railroads leading from the city have an immense and ever-increasing traffic; and they directly connect the metropolis with every important section of the country. The receipts of the city from the Erie Canal are approximately known, because the greater part of the receipts at tide-water at Hudson, near Albany, from the same source, are directly sent to New York. The following statement shows the aggregate tonnage and value of the property which came to the Hudson River, on all the canals, during the year 1856:—

Trade with the interior.

	Tonnage.	Value.
Product of the Forests	858,771	L.2,176,431
Agriculture	1,023,417	10,379,644
Manufactures	50,454	934,199
Merchandise	14,073	1,103,685
Other articles	176,754	882,365
Total	2,123,469	L.15,476,324

Of the total tonnage, the amount from Western States and Canada, arriving by way of the Erie Canal, was 1,212,550. The amount of the produce of the state of New York, arriving by all the canals, was 374,580 tons. Number of barrels of flour by all the canals, 1,130,509; bushels of wheat, do., 11,776,332 (or 2,355,266 barrels of flour; total, 3,485,775 barrels wheat flour); bushels of corn, do., 9,587,714.

The property which went up the canals in 1855 was in tons 638,597, and in value L.23,634,234; the same in 1856 was in tons 650,943, and in value L.27,944,001. Aggregate of property brought and taken in 1855, L.39,667,732; in 1856, L.43,420,325.

Foreign commerce.

In surveying the business of New York, and comparing it with that of other American cities, it is at once seen that the point in which it is relatively greatest is its foreign commerce. From this source, more than any other, New York derives its general pre-eminence. Compared with the other great seaports of the world, the ocean commerce of New York is more extensive than any, excepting perhaps London and Liverpool. For this branch of industry the city naturally possesses uncommon advantages; but its remarkable prosperity has been owing mainly to the enterprise of its merchants. The following table is a summary view of the percentage of New York in the entire foreign commerce of the United States, at intervals of five years from 1825:—

Fiscal Years.	Tonnage entered.	Tonnage cleared.	Value of Exports.	Value of Imports.	Duties collected.
1825	26·21	21·65	44·80	51·92	78·37
1830	27·78	24·19	23·93	54·54	68·48
1835	23·35	13·12	23·86	59·58	74·61
1340	23·41	17·38	22·85	53·05	55·84
1845	19·66	16·22	29·83	58·78	64·18
1850	26·33	22·52	25·44	57·96	61·73
1855	29·20	23·40	36·48	59·09	61·58
1857	28·38	24·82	34·27	61·67	...

Tonnage entered and cleared from New York.

The next two tabular statements, derived from the "United States Treasury Report on Commerce and Navigation," exhibit the number of vessels and amount of tonnage entered into and cleared from the district of New York for foreign ports, in each fifth year from 1826. The years end with September to 1840, thence with June:—

Vessels and Tonnage entered into District of New York. New York City.

Fiscal Years.	American		Foreign		Total	
	Vessels.	Tonnage.	Vessels.	Tonnage.	Vessels.	Tonnage.
1826	...	248,176	...	26,285	...	274,461
1830	...	273,790	...	31,391	...	305,181
1835	1,528	374,602	480	91,063	2,008	465,665
1840	1,443	417,443	512	128,488	1,955	545,931
1845	1,450	439,676	558	139,542	2,008	579,218
1850	1,882	734,431	1,281	410,900	3,163	1,145,331
1855	2,588	1,377,738	1,185	358,169	3,773	1,735,907
1857	3,014	1,584,764	1,054	450,885	4,068	2,035,649

The number of arrivals from foreign ports entered at the custom-house is always greater than the official record of clearances, because many vessels entering from abroad clear for a coastwise port.

Vessels and Tonnage cleared from District of New York.

Fiscal Years	American		Foreign		Total	
	Vessels.	Tonnage.	Vessels.	Tonnage.	Vessels.	Tonnage.
1826	...	208,202	...	19,655	...	227,857
1830	...	210,535	...	32,620	...	243,155
1835	1,226	289,268	433	77,121	1,659	366,389
1840	1,067	283,149	503	125,619	1,570	408,768
1845	1,127	341,094	561	142,431	1,688	483,525
1850	1,379	596,812	1,230	385,666	2,609	982,478
1855	1,941	1,091,244	1,169	354,510	3,110	1,445,754
1857	2,307	1,310,875	1,047	445,566	3,354	1,756,441

Imports, duties, and exports.

The next tabular statement exhibits the value of imports, the duties collected thereon, and the value of exports in each fifth fiscal year from 1820. The years end with September 30th to 1840, and thereafter with June 30th:—

Fiscal Years.	Value of Imports.	Duties collected.	Value of Exports.
	L.	L.	L.
1820	...	1,143,325	2,451,978
1825	10,419,783	3,281,684	7,089,824
1830	8,053,342	3,127,613	3,680,542
1835	18,278,089	2,416,135	6,135,661
1840	12,515,526	1,493,323	6,751,805
1845	14,561,955	3,594,852	6,990,573
1850	24,305,736	5,198,532	9,912,571
1855	32,188,648	6,803,926	20,912,898
1856	41,314,728	8,880,935	22,042,927
1857	47,121,696	8,808,589	26,376,387

Imports classified.

The returns previous to 1852 are from a United States Treasury document, and those of subsequent years are from the statements published in Hunt's *Merchants' Magazine*. The latter also presents the following classification of imports and exports:—

Foreign Imports.	1856.	1857.
Entered for consumption	L.31,268,354	L.29,464,603
Entered for warehousing	6,160,078	12,974,093
Free goods	3,631,686	3,340,940
Specie and bullion	234,600	1,342,050
Total entered at the port	L.41,294,718	L.47,121,686
Withdrawn from warehouse	4,569,606	5,822,957

The imports in 1857, at New York, were even greater than the total imports into the whole United States in any fiscal year previous to 1853. Prior to 1855 about one-half of the imports at this port were dry goods, but since that date the enormous increase has been chiefly in general merchandise:—

Years.	Dry Goods.	General Merchandise.	Total Imports.
	L.	L.	L.
1854	19,247,841	20,559,344	39,807,185
1855	13,108,005	19,080,638	32,188,643
1856	17,895,555	23,399,168	41,294,723
1857	19,312,304	27,809,387	47,121,691

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Description of Dry Goods Imported for Two Years.

Articles.	1856.	1857.
Manufactures of wool.....	L.5,178,249	L.5,488,085
Manufactures of cotton.....	3,173,270	4,082,083
Manufactures of silk.....	6,242,410	6,185,393
Manufactures of flax.....	1,796,205	1,893,034
Miscellaneous dry goods.....	1,505,399	1,657,523
Total dry goods.....	L.17,895,533	L.19,306,118

Which were disposed of as follows:—

Entered for consumption.....	L.16,243,806	L.15,590,337
Entered for warehousing.....	1,651,727	3,715,781

Under the inducement to await the operation of the new tariff, which provided for an important reduction in duties on 1st July 1857, the stock in bonded warehouses had on that day accumulated to the amount of L.7,695,466, against the corresponding value of L.2,928,627 one year previous.

Exports classified, &c.

The exports to foreign ports during the fiscal year 1857 were larger, both in specie and produce, than during any previous year. Classification for two fiscal years:—

Articles.	1856.	1857.
Domestic produce.....	L.15,630,464	L.15,818,526
Foreign merchandise, free.....	264,354	499,350
Foreign merchandise, dutiable,	769,079	819,239
Specie and bullion.....	5,379,018	9,239,260
Total exports.....	L.22,042,915	L.26,376,375
Total, exclusive of specie.	16,663,897	17,137,115

Moneyed institutions.

For a series of years the city of New York has proved to be the regulator of the policy adopted in financial affairs throughout the Union, and may now be considered as its financial centre. This has naturally resulted from its being the leading channel of imports and exports; and thus it has become the pivot upon which almost the whole business of the country has turned. Since 1849 this has especially been the case, by the constant influx of vast amounts of gold from California; which, being brought first of all into the city of New York, has materially aided in augmenting the number and capital of all classes of its moneyed institutions. Meanwhile, other causes have been producing a gradual and powerful concentration of capital at New York from all parts of the Union. During the same period the banks and private bankers of every state have increasingly made this city the depository of their surplus funds, and more particularly since the practice of allowing from 4 to 6 per cent. interest has prevailed. Hence, of late years, exchange on New York has been considered as equivalent to cash funds on hand by all engaged in the banking business. New York has for many years been a creditor of the whole Union. Thereby it has obtained a vast credit, and, consequently, the control of immense capital, belonging, in small and large sums, to remote parties. This rapid accumulation of capital has not only aided to build up New York, but it has at length been regarded as belonging permanently to the interests of the city. From 1849 to 1857 the imports of New York increased 133 per cent.; the bank capital 160 per cent.; the average bank loans 125 per cent.; and the average bank deposits about 225 per cent.

In 1830 the capital of the banks in the city was L.3,183,330; on 1st February 1834 (twenty-one banks) L.3,929,472; and on 1st January 1837 (twenty-four banks) L.4,346,080. The general banking law was passed by the legislature 18th April 1838. In 1845 the number of banks was twenty-four, and their capital L.4,809,184; and there was no increase until 1849. In that year the capital was raised to L.5,095,390; at the close of 1850 it was L.5,634,645; in July 1852 (forty banks), L.7,465,610; in January 1854 (fifty-seven banks), L.9,928,622; in July 1856, L.11,077,146; and in July 1857 (fifty-six banks), L.13,453,352.

Without presenting an account of the progress of the banks during a series of prosperous years, and their usual operations in such years, we shall briefly sketch the features of their condition through the year 1857, which opened favourably with a very buoyant stock market. Throughout January money was in good demand, and a moderate stringency existed. In February the rates gradually declined, and stock securities were pretty well sustained. In March there was more active movement, with an advance in prices. In April money was abundant, and the banks gradually increased their discount lines upon an increasing specie basis and a larger deposit account; and on the 11th of the month their loans were L.24,036,395, being a higher point than ever before known. The highest point in 1856 was 2d August, L.23,381,488; and the highest in 1855 was on 1st September, L.20,924,365. Through May the money market was easy, stocks were buoyant, and the banks maintained a very uniform movement in the discount and specie departments. On 6th June the loans and discounts were L.24,028,868, and for four weeks remained above L.24,000,000, and at about the same amount; but in that time the specie decreased from L.2,736,395 to L.2,271,058, owing to the active shipments. From 3d July the loans increased daily until 8th August (the highest point of the expansion), when they amounted to L.25,432,756, being an increase of L.1,454,796 in *five weeks*, or at an average of L.48,489 *each business day*. With this expansion in discounts there was a steady *decrease* in the specie reserve. During the last of the five weeks just mentioned the loans and discounts increased L.308,373, while the specie decreased L.245,965. Thus, on the 8th August, the loans and other chief items of the accounts of all the banks in the city were, in comparison with their condition on 3d January, as follows:—

New York City.

The banks in 1857.

Date.	Loans.	Specie.	Circulation.	Deposits.
	L.	L.	L.	L.
Aug. 8.....	25,432,756	2,445,281	1,871,192	19,674,249
Jan. 3.....	22,739,402	2,327,547	1,792,104	19,967,957
Increase...	2,693,354	117,734	79,088	
Decrease in deposits.....				293,708

Apprehensions of coming troubles were immediately excited in the minds of many financiers. Thenceforward the banks rapidly contracted their loans; at the same time their specie reserve ran down, and the money market daily became more stringent. The remarkable extent of this contraction is readily apparent from the following tables:—

Increase of the Currency, &c., in Nineteen Weeks.

Date.	Loans.	Specie.	Circulation.	Deposits.
	L.	L.	L.	L.
Aug. 8.....	25,432,756	2,445,281	1,871,192	19,674,249
Mar. 28.....	23,517,502	2,359,523	1,765,378	19,294,696
Increase	1,915,254	85,758	105,814	379,553

Decrease of the Currency, &c., in Four Weeks.

Date.	Loans.	Specie.	Circulation.	Deposits.
	L.	L.	L.	L.
Aug. 8.....	25,432,756	2,445,281	1,871,192	19,674,249
Sept. 5.....	23,379,447	2,131,239	1,806,910	16,560,687
Decrease...	2,053,309	314,042	64,282	3,113,562

The foregoing statements show that the contraction in four weeks after 8th August, was much greater than the expansion in nineteen weeks before that date.

The next table shows, on comparison with the first table, that the contraction in six weeks after 8th August was also much greater than the expansion during the thirty-one weeks before that date; viz., from 3d January:—

New York City.

Decrease of the Currency, &c., in Six Weeks.

Date.	Loans.	Specie.	Circulation.	Deposits.
	L.	L.	L.	L.
Aug. 8.....	25,432,756	2,445,281	1,871,192	19,674,249
Sept. 19....	22,661,960	2,824,200	1,682,039	15,785.991
Decrease ...	2,770,796		189,153	3,888,258
Increase in specie reserve		378,919		

On 26th September the banks in Philadelphia and Baltimore suspended specie payments; but the banks in New York city, and in part of New England, published that they were able to maintain themselves as specie-paying institutions. This announcement inspired hope; but the banks, instead of giving to their customers the expected (and in fact promised accommodation), continued to diminish their loans. The financial panic waxed more intense, surpassing description. Commencing in August, business of almost every kind was gradually brought to a stand. In almost every place the operations of manufactories, and shops and stores, were reduced; and thousands of operatives and employés were discharged. Through September the gloom deepened every day. Men were everywhere calling for aid, and in vain. Property seemed to have no fixed or certain value. In the fore part of October the number of mercantile suspensions and failures augmented rapidly over the corresponding daily announcements in September. The paper of many of the most prominent and reputable mercantile firms, of several of the largest private banking-houses, and of some great railroad corporations, was protested. The suspension of a few of the banks in the city, and of a score of those in the interior of the state, and perhaps a hundred in other states, aided in bringing about the general suspension by inducing a general run upon all other banks. On Tuesday, 13th October, nineteen banks ceased to pay specie to bill-holders and depositors; but to the latter either paid notes or closed their doors entirely. In the evening of that day all other banks resolved to suspend on the ensuing day. This course was immediately followed throughout the Union.

It is generally considered that the panic which brought on the crisis was owing chiefly, if not wholly, to the imprudent course of the banks in expanding their discounts, and then too suddenly contracting them. The actual suspension of the banks was owing to the disgust and indignation of the mercantile classes, who, having been injured by the banks, retaliated by using their own power. On this point, the London *Times* of 26th October remarked that—"The entire suspension of specie payments by the New York and Boston banks, reported this morning by the American mail, is the most satisfactory announcement that could have been looked for. Had the step been taken a fortnight earlier, an immense amount of ruin might have been averted. The banks, after having, by their mismanagement, brought about the state of affairs which rendered the panic possible, sought to save themselves by the sacrifice of the whole mercantile community; but the public, at last, took the matter in their own hands, and forced them to a stoppage, which placed them in the same condition with their victims, and thus terminated the struggle." The *Times* regarded the matter in its true bearing, attributing the blame to the proper parties.

The returns for the week of suspension, ending 17th October, being ten weeks from 8th August, are thus compared with the returns of that date:—

Date.	Loans.	Specie.	Circulation.	Deposits.
	L.	L.	L.	L.
Aug. 8.....	25,432,756	2,445,281	1,871,192	19,674,249
Oct. 17.....	20,259,543	1,634,003	1,684,881	11,019,709
Decrease...	5,173,213	811,278	186,311	8,654,540

showing several still greater changes in each item, and particularly in the decrease of specie and deposits, these having been withdrawn by bill-holders and depositors. New York City.

After suspension the banks rapidly augmented their specie to a sum several millions above any previous total, gaining from 17th October (when L.1,634,003) to 12th December (when L.5,428,928) the sum of L.3,794,925. But no ease in the money market was realized amongst business men for seven or eight weeks, and there was no important change in financial affairs until 11th December. On that day the specie in the banks had accumulated to L.5,415,000, and it was then resolved to resume specie payments on the next day. In the first week after resumption the specie increased nearly L.415,000, swelling the amount to L.5,824,855, in the face of a very active shipment to foreign ports. At the close of the year the banks of Philadelphia, Baltimore, &c., had not resumed.

Although it is reasonable to suppose that another revulsion may occur in an interval of twenty years, it is probable that this of 1857 will produce at least three beneficial results throughout most of the states, viz.,—The abolition of small bank notes (under L.1 or L.2); the establishment of a specie basis of not less than 1 to 3 (or 4) of circulation; and the requirement of ample securities for bill-holders and depositors.

On 1st January 1857 there were sixteen savings-banks in the city, which had on deposit L.6,760,879. Number of depositors' accounts, L.151,559. During 1856 there were 193,317 deposits, amounting to L.3,053,992; and 139,422 withdrawals, amounting to L.2,412,978. Interest received on stocks and securities, L.1,855,110. Interest received on bonds and mortgages, L.181,854. Interest allowed to depositors, L.286,973. Savings-banks.

The daily newspapers, with many of the weeklies and other periodicals, are remarkable for their intrinsic merits, size, cheapness, and immense circulation. Each of the leading newspaper establishments employs a very large amount of capital, and is furnished with the best presses and other equipments known among printers. The earliest newspaper in New York was commenced on 16th October 1725, and printed weekly. Before the Revolution about 90 others had been in existence. In 1775 there were 4 newspapers. In 1832, 64 newspapers and periodicals. According to the census of 1855, there were in that year 145 newspapers and 78 other periodicals, published as follows:—Daily, 19; tri-weekly, 1; semi-weekly, 8; weekly, 87; semi-monthly 10; monthly, 87; quarterly, 13; semi-annually, 2; annually, 3. Four of the daily papers are reputed to have each a circulation above 30,000 (their proprietors not unfrequently claim much more); and several of the weeklies circulate to regular subscribers each from 40,000 to 50,000 copies. One weekly, devoted to news and politics, has 175,000 of a regular circulation, almost wholly to subscribers; while another, devoted to tales and "light reading," is believed to have above 300,000. One of the popular monthly magazines has 170,000, and a religious monthly newspaper above 200,000. The press.

The public and private provisions for the general education of children, youth, and adults, are upon a liberal scale. It is believed that less attention is given to education by the illiterate and poor classes than in most large cities of the Union; but these are chiefly of foreign birth, and feel compelled to make use of their children to gain a livelihood. By the census returns it appears that the greater number of the adults unable to read and write are of foreign birth. Education.

The number of public schools under the jurisdiction of the Board of Education, in the year 1855, was 271, viz.,—Grammar, for boys, 47; grammar, for girls, 48; primary, 101; coloured, 14; corporate and asylum, 28; evening, 29; normal, 3; and the Free Academy. The whole num- Public schools.

New York City.

ber of teachers employed in the several schools was 1067, consisting of 187 males, and 880 females. The amount expended for purposes of education during the year was L.191,217; of which the sum of L.27,649 was received from the state funds, and L.163,568 raised by tax on property in the city. In the grammar and primary schools (238) the whole number taught in 1855 was 137,874; the annual average attendance was 47,858; and the cost (total L.112,507) per pupil was, on the whole number taught, 15s. 5d.; on average annual attendance, L.2, 4s. 5d. The evening schools, for adults, &c., were attended by 12,762 persons, and their support cost L.6796. The normal schools, with 782 pupils, cost L.1256 for support. The Free Academy, established in 1848, crowns the system of public school education. In 1855 it had 696 pupils, and its support cost L.7714. Its spacious edifice is built in the Gothic style, after the manner of the town-halls of the Netherlands, and cost, with site and fitting up, L.22,811. It has 23 teachers, a library of 5000 volumes, besides 10,000 text-books, &c., excellent apparatus, laboratory, and cabinets.

Academies. Select schools and academies, conducted by individual and associated enterprise, are proportionately numerous. Some of the seminaries for young woman are of very high reputation, and have each several hundred pupils.

Colleges. Columbia College was founded in 1754 by royal charter as King's College, and received its present name in 1784. Its trustees and officers are of the Protestant Episcopal Church. It is richly endowed, possesses a valuable library, and has usually about 120 students in its collegiate department. It occupied its ancient position near the city-hall, in beautiful open grounds, shaded by venerable trees, until 1857, when it was removed to the upper part of the city, and its former site is now covered with warehouses. The university of the city of New York was founded in 1831, and is non-sectarian. Its edifice, fronting Washington Square, is one of the finest structures in the city, and the most costly collegiate building in the country. It is constructed of marble, in English Gothic architecture; and its central part, used as the principal chapel, is an imitation of the celebrated King's College chapel, Cambridge, England. There are three flourishing medical colleges, and several minor medical institutes. The College of Physicians and Surgeons was founded in 1807; medical department of the university in 1837; and New York medical college in 1851; each of which has an excellent edifice, and is well furnished with a library and cabinet. There are two theological seminaries,—the Episcopal, founded in 1817, and richly endowed; and the Union (Presbyterian), founded in 1836,—each possessing a large and very valuable library.

Institutions and libraries. The Cooper Institute, or the "Union," devoted to science and art, is an important establishment, founded by Mr Peter Cooper, at a cost of L.62,500, for the educational advancement of the youth and people of the city. Its handsome edifice, of freestone, six storeys high, and covering 20,000 square feet of ground, is unusually substantial, and fireproof. The American Institute, incorporated in 1829, for the encouragement of commerce, agriculture, and manufactures, has a building, containing a library of 8000 volumes and repository for models, in which weekly meetings are held for scientific objects; but this organization is especially noted for its annual exhibitions of national industry. The Mechanics' Institute has 5000 volumes, a good collection of philosophical and chemical apparatus, and regular courses of lectures. The Historical Society, founded in 1804, possesses an extremely valuable library of 25,000 volumes, and interesting collections, safely deposited in its fireproof edifice. It has published numerous volumes on American history. The Geographical and Statistical Society, founded in 1851, holds frequent meetings, and has about 3000 volumes. The total number of volumes in the public libraries and institutions in 1855 was 336,290; of which, in the Astor Library, 80,000; Mercantile, 47,000; Society, 40,000, &c. The Astor Library was founded by John Jacob Astor, by his bequest of L.83,000, which directed that L.15,600 should be expended for a building, L.25,000 in a first outlay for books, and the residue, or over L.42,000, invested as a fund for the maintenance and increase of the library. The Mercantile Library Association, formed in 1820 for merchants' clerks and others, is one of the most useful organizations in the city, has 5100 regular members, and an annual revenue of over L.2000. Since 1854 it has occupied the building formerly known as the Astor Place Opera House.

New York City.

Fine-art, societies, galleries, &c. The National Academy of Design, the chief art institution of America, was founded in 1826, since which time it has steadily advanced in influence and usefulness. It numbers among its academicans and associates nearly all the eminent artists of the city and vicinity. It supports free schools for the study of the antique and living models; possesses an extensive and valuable art library; makes annual exhibitions of original works by American and foreign painters and sculptors, &c. The New York Gallery of the Fine Arts is a permanent collection of American art, commenced a few years ago, containing many valuable works, but not yet accessible to the public, through want of a suitable and permanent gallery. The Dusseldorf Gallery is an admirable exhibition of the works of German painters, chiefly of the Dusseldorf school, in the building erected and formerly occupied by the late American Art Union. The Bryan Gallery of Christian Art is an extremely interesting and valuable collection of the works of the old masters. Several shops in Broadway, for the sale of oil-paintings, engravings, picture-frames, artists' materials, &c., keep up a rich display of works of art.

Places of amusement. Theatres and other places of amusement are comparatively numerous and well patronized. Some of them are very large and elegant establishments. The building of the Academy of Music (or new opera house), completed in October 1854, has 4600 seats; it cost L.57,000, and its site L.12,500,—total, L.69,500. Among other permanent amusements are several companies of Ethiopian minstrels; and the changing attractions include an endless number of panoramic exhibitions, concerts, balls, &c.

Private and incorporated benevolent institutions. The benevolent or charitable institutions of a public nature, founded and sustained by special associations, are highly creditable to the citizens. These are numerous, and some of them very extensive. The list embraces 9 hospitals, 3 infirmaries, 6 dispensaries, 7 homes for the relief of certain unfortunate classes, 4 homes for the aged and indigent, 2 houses of industry, besides the missionary establishments, and very many aid societies. In the upper part of the city are the institutions for the blind, deaf-and-dumb, and insane, each having spacious buildings, with beautiful grounds. There are extensive institutions for seamen on Staten Island, 6 miles from the Battery.

Public charities. Most of the public institutions maintained by the city government are situated on the islands in the East River. The almshouse and its hospitals, lunatic asylum, workhouse, and city penitentiary, are on Blackwell's Island. The Nursery and various establishments for children, and the house of refuge, are on Randall's Island. Ward's Island is occupied with the hospitals, &c., under the charge of the Commissioners of Emigration.

Religious and moral societies. New York contains many of the central offices and publication establishments of those great religious societies and denominations which embrace in their labours the whole country. Some of their printing-offices are among the largest in the city,—as those of the American Bible Society; American Tract Society; Methodist Book Concern; &c. In 1852 the Bible Society erected, at a cost of about L.62,500, a new building, six storeys high, and comprising

New York City.

an entire block; part of it being occupied by offices of other societies.

Churches.

Synopsis of the census returns on churches:—Number of churches in 1850, 214; in 1855, 252; aggregate accommodation in 1850, 219,098; in 1855, 234,730; value of church property in 1850, L.1,895,559; in 1855, L.2,519,319, consisting of L.2,270,916 as value of churches and lots, and L.248,403 as value of other real estate. Twenty-seven sects were mentioned in returns of 1855, from which are taken the following statistics of the chief denominations:—

Religious Denominations.	Church Edifices.		Usual Attendance.	Church Members.
	No.	Value.		
		L.		
Baptist	26	131,622	12,140	7,116
Congregational	9	60,935	4,175	905
Jews	10	36,894	3,825	1,953
Methodist Episcopal	33	121,414	15,090	8,878
Methodist African	6	25,000	3,005	1,668
Presbyterian (Old & New School)	33	324,810	17,675	10,643
Presbyterian, Associate	6	78,748	3,700	1,708
Protestant Episcopal	43	700,844	21,850	9,006
Reformed Protes. Dutch	22	191,456	13,100	5,117
Roman Catholic	24	335,415	100,500	78,488

The most costly and conspicuous ecclesiastical edifices are those of the Protestant Episcopal denomination. Of these Trinity Church, built entirely of freestone, including the tower and spire, 264 feet high, cost L.83,000, and is the noblest building of Gothic architecture in America; and Grace Church, a very elaborate structure of white marble. cost L.42,000.

Croton Aqueduct.

The Croton Aqueduct is the greatest and most important public work, and is not only superior in grandeur and costliness to anything of the kind on the globe in modern times, but to any work ever executed by a comparatively small community. In April 1835 the plan for its construction was ratified by the electors by a vote of 17,330 for, to 5963 against it. In July ensuing the surveys were commenced; in the spring of 1837 the work was fairly begun; and on the 14th October 1842 its completion was celebrated. Its cost to 1843 was L.2,386,158. The pond, now called Croton Lake, formed by the dam of Croton River, is 5 miles in length; the aqueduct from this dam to the distributing reservoir is 40½ miles; and the large mains from this reservoir, through the central part of the city to the Battery, add 4 miles, making the total length of the main conduit 50 miles. The aqueduct, built of stone, brick, and cement, has form and dimensions as follows:—The bottom is an inverted arch; the chord or span line is 6 feet 9 inches, and the versed sine 9 inches; the greatest interior width is 7 feet 5 inches; and the greatest depth 8 feet 5½ inches. For the first 5 miles the side walls have an extra height. It crosses Harlem River on a magnificent bridge, 1450 feet long, constructed of well-dressed granite, with 15 arches, the under side of which is 100 feet above high tide, completed in 1849, at a cost of L.200,710. Its general declivity per mile is, in its upper part, 13¼ inches, and in its lower part, 9 inches. The dam covers about 400 acres, and is available as a reservoir for 500,000,000 gallons above the level that would allow the aqueduct to discharge 35,000,000 gallons daily. The receiving reservoir, 5 miles from City Hall, contains an area of 35 acres, is divided into two equal parts, and has a capacity for 150,000,000 gallons. The distributing reservoir, 3 miles from City Hall, includes 4 acres, is also divided into two equal parts, and has capacity for 25,000,000 gallons. Its walls consist of an exterior and an interior wall, connected at every 10 feet by cross walls. At their base the thickness of the interior wall is 6 feet, of the exterior 4 feet, and the intermediate space is 14 feet; or 24 feet in all. Both walls are carried 5 feet beneath the ground, and the exterior 44½ feet above it. The new reservoir, in the Central Park, begun in 1856 covers 97 acres; the cost of its construction is estimated at L.250,000; amount awarded for the land, L.147,500. The total length of street pipes laid to 31st December 1856 was 255 miles. The entire water receipts to that date amounted to L.1,103,823.

New York City.

Fire department.

The fire department of the city is a powerful organization, effective in the preservation of life and property. The city is divided into eight fire districts; and in case of fire the alarm bells are struck according to the number of the district in which the fire exists. The name of the locality is signalled to the bell-ringers by telegraph. There are 46 fire-engine companies, 57 hose companies, and 13 hook and ladder companies; nearly all of which are well supplied with the necessary apparatus for efficient service. There are also 4 hydrant companies, whose duty it is to take charge of the hydrants at fires. The fire marshal's reports afford the following statements:—

Items returned.	June 1st to May 31st.		Decrease in 1855-6.
	1854-5.	1855-6.	
Number of fires	353	331	22
Alleged loss	L.288,994	L.192,335	L.96,656
Insurance	645,140	583,952	61,186
Amount paid	288,994	103,605	185,387

The permanent fund of the fire department, for the relief of widows and children of its deceased members, exceeds L.20,000; and the annual accounts of its payments for relief, have of late years ranged from L.3000 to L.4100.

Gas-light.

Gas-light is supplied by two companies, of which we have the following statistics:—The New York Gas-Light Company, chartered in 1823, with a capital of L.208,000, supplies the district south of Grand Street; and in 1856 had about 130 miles of mains of various sizes, and lighted 3500 public lamps. The Manhattan Gas Company, chartered in 1833, with a capital of L.416,000, supplies the rest of the city; and in 1856 had 190 miles of mains, lighted 7300 street lamps (in 1850, 3797), and furnished gas to over 17,000 shops and dwellings. The following is a statement of the assessed valuation of these companies in 1856:—New York,—personal estate, L.70,286; real estate, L.121,248: total, L.191,534. Manhattan,—personal estate, L.274,570; real estate, L.180,666: total, L.455,236.

The city government.

The city charter, as it now stands, according to the Act of Amendment of 14th April 1857, provides, that the corporate name of the body politic shall, as formerly, be "the mayor, aldermen, and commonalty of the city of New York." The legislative power is vested in the common council. This body consists of the Board of Aldermen and the Board of Councilmen. The former comprises 17 members, each elected for two years, 8 or 9 retiring annually. The Board of Councilmen consists of 24 members, 6 from each senatorial district, elected on general ticket. Both aldermen and councilmen must, at time of election, be residents of the districts from which elected. Executive power is vested in the mayor, who is elected for two years. There are 6 executive departments, the heads of which are appointed by the mayor, with approval of the Board of Aldermen. The various departments of city business are duly arranged according to statute. The expenses of the government have for many years been constantly increasing. During 1856 the total amount received into the treasury from all sources, except the sinking fund, was L.3,700,551; and the expenditure therefrom was L.3,589,312; showing an excess in receipts of L.111,239. The principal items in the accounts were of the sale of new city bonds, and the redemption of bonds due: The expenditures for the support of the city government proper were L.956,231. The permanent city debt

New Zealand.

(chiefly for the Croton Aqueduct) on 1st January 1857, was L.2,964,712, and the amount then held by the commissioners of the sinking fund towards its payment was L.1,152,071, leaving as the outstanding debt unprovided for L.1,825,037. Amount received on account of the fund in 1856, L.253,723; interest paid on city stock in 1856, L.173,758; amount of funded debt redeemable from taxation, 1st January 1857, L.240,415; amount of city debt cancelled in 1856, L.117,926; in the early part of 1857 the sum of L.206,248 was paid on account of the aqueduct loans. The total operations of the city treasury for the years 1855 and 1856 were:—

Receipts in 1855,	L.3,545,850.	In 1856,	L.4,315,939.
Payments in 1855,	3,444,555.	In 1856,	4,236,276.

The total amount of tax (including the state tax) levied in each year, from 1851 to 1856 inclusive, was:—

In 1851	L. 609,233	In 1854	L.1,008,591
In 1852	703,816	In 1855	1,217,459
In 1853	1,066,173	In 1856	1,474,045

The value of the real estate owned by the city in February 1857 was L.9,002,511 (as estimated, being chiefly unproductive, at its cost price); of which the aqueduct L.3,370,247; parks, L.2,913,406; piers and bulkheads, L.1,213,122 (those used for commerce, L.842,915; for ferries, L.336,873; for corporation purposes, L.33,334); almshouses, L.354,166; schoolhouses, L.332,038; markets, L.245,164. (F. H.)

Situation and area.

NEW ZEALAND consists of three islands of unequal size, situated in the South Pacific Ocean, between the parallels of 34. and 48. S. Lat., and of 161. and 179. E. Long. The northern island, called by the natives *Eaheinomawe* ("The Child of Mawe"), is of very irregular shape, the northern portion being a narrow peninsula, varying from 8 to 50 miles across, the centre widening to a breadth of 200 miles, and then decreasing to an average of 60 or 70 towards its southern extremity. Its length, as measured by a line drawn from Cape Maria Van Diemen to Cape Palliser, is 540, and the breadth between Cape Egmont and East Cape, 290 miles. The actual surface extent is not more than 48,710 square miles, or 31,174,400 acres. The middle island, called by the natives *Tavai Poenammoo* ("The Land of Green Talc"), extends from N. to S. about 470 miles; the breadth from E. to W. varies from 100 to 170 miles; and its area is computed at 72,072 square miles, or 46,126,080 acres. The southern island (called also *Stewart's Island*) is about 60 miles long, and 30 broad; its area being about 1800 square miles, or 1,152,000 acres. Thus the area of the three islands is estimated at 78,452,000 acres, being about 1,192,160 acres beyond the extent of the islands of Great Britain and Ireland. The names of New Ulster, New Munster, and New Leinster, attempted to be imposed upon these islands by the Colonial Office, have been disregarded by the British colonists, who desire for their adopted country a nomenclature more suitable to its future position among the nations of the Southern World. Zeelandia, Australian Britain, and South Britain, have been proposed, as being more euphonious and descriptive, and it is probable that one of these will in due time be adopted by the general legislature.

Geological formation.

That these islands are of volcanic origin, admits of no question. At no very distant period their whole area presented the appearance of a group of rocky islets, precipitous and barren, except in the gullies of the mountains. New Zealand largely participates in a general elevatory movement, extending from the southern pole over the whole Southern Hemisphere. Besides this, she has her own centres of volcanic action, some of which are yet in operation, gradually raising the level of the land; the proofs of which in the upheaving and increase of elevation are even now obvious to any intelligent traveller. Some of these changes have been witnessed by the present generation. (Forbes.) These centres of volcanic action are supposed to be—(1.), at Otawa, near the Bay of Islands; (2.) the vicinity of Auckland; (3.) a range of country which may be defined by a line drawn from White or Sulphur Island to Rotorua, Lake Taupo, and Mount Tongariro, to Wanganui; (4.) the country around Wellington. (Taylor.) In the middle island the upheavement of the land is observable in a marked manner through the entire length of the western coast from Cape Farewell to Dusky Bay. Some of the most extraordinary changes in these regions have taken place within the last few years. More than half of the mountains of New Zealand are extinct volcanoes; a few are yet in partial action, as Waka-ari (White or Sulphur Island), Montohoro (Whale Island), Tongariro, and occasionally one of the Kaikora peaks. In the centre of the northern island, between Rotorua, Lake Taupo, and Mount Tongariro, the number of boiling mud pools, mud volcanoes, and openings emitting sulphureous steam, is astonishing. Some of them shoot up volumes of boiling water, like the geysers of Iceland, to which they are little, if at all, inferior. Earthquakes, as might be expected, occur occasionally; but their action appears now to be confined to the shores along Cook's Straits, and the western coasts of the middle island. The geological formation is simple, the rocks being erupted, metamorphic, trappean, and sedimentary, the latter all of them of tertiary origin, as proved by their imbedded fossils. (Forbes.)

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Face of the country.—The mountain ranges.

New Zealand is eminently a mountainous country, level plains, though such there are of great extent, being the exception. The mountain ranges run parallel with the sea-coast, generally from N.E. to S.W. In the northern island these ranges vary from 500 to 1500 feet in height, until they reach the centre of the island near Mount Pirongia, where the great central Rangitito chain commences, which, under the names of Ruahine and Tarahua, extends as far as the southern extremity. "This central mountain range throws off spurs or ridges of a very difficult mountainous country in various directions to the coast; the valleys between these ridges, generally mere gorges at the hills, become fertile and extensive plains near the coast; and form the channels of the Thames, the Waikato, the Mokau, the Wanganui, the Rangitiki, and other minor streams. These subsidiary mountain ridges or spurs, thrown from the main range, are for the most part, where roads have not been constructed across them, impassable even for horses; so that no overland communication, except for foot-passengers, can be considered as yet existing between the several principal settlements." (Sir George Grey.) Some of these mountains are very elevated, and are covered with perpetual snow. Pirongia is only 2500 feet high; but Tongariro is 6200 feet, and Ruapahu 9000 feet in height. Though not connected with any of the central or minor ranges, Mount Egmont or Taranaki stands about 30 miles from the sea, and rises to an elevation of nearly 9000 feet; it is distinguished by the perfect shape of its cone, covered with perpetual snow. The middle island has its northern shores skirted by a high crescent-shaped range of mountains, throwing out spurs towards the sea, and forming the sheltered harbours in which that locality abounds. This range unites with a great central range which runs through the island midway, and with another of yet greater elevation which skirts the western coast, and which approaches even to the very margin of the sea. Numerous streams subject to sudden floods flow from these ranges. The highest peak in New Zealand, Mount Cook, which rises to about 13,000 feet above the level of the sea, is one of the mountains of this western range.

Scenery.

The appearance of the country generally is singularly picturesque and attractive. "It may be called a wooded highland country, displaying some half dozen noble plains,

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and thousands of brook-watered valleys, dells, and dales. In combination of those great natural features which constitute the foundation of fine scenery, New Zealand is unsurpassed by any country in the world. She displays noble forests, snow-capped mountains, shooting up 10,000 feet from a sea of green, and wooded up to the line of snow; tracts of rolling champaign country, dells, valleys, rivers and rivulets innumerable; and 3000 miles of bay and ocean coast. The indigenous plants and trees being evergreen, there is no autumnal fall: the country is always verdant." (Hursthouse.) To the truth of this glowing picture we can bear testimony.

Soil.

The soil is generally fertile: the swamps may be easily drained, and will afford the best land to reward the labours and enterprise of future capitalists. There is perhaps as large a proportion of available land for agricultural and pastoral purposes as in the British Islands; and it must be kept in mind, that the grazing capabilities, as well as the results of husbandry in general, are fully equal to a similar extent of land in Britain. "Every English grain, grass, fruit, and flower attains full development and perfection. Surface and subsoil are generally light and porous: wet rapidly drains and percolates away." (Hursthouse.)

Climate.

The climate is undoubtedly one of the best in the world, and is peculiarly congenial to English constitutions and tastes. The summer is a little warmer than in England, and of longer duration; and winter, spring, and autumn, are much milder. Rain and heavy dews are frequent, but there are more fine days than in England; the high winds are perhaps the greatest inconvenience felt by strangers. Snow is never seen in the northern island, except on the mountain-tops; but there are occasional falls on the Canterbury and Otago plains in the middle island. Fogs and mists are rare, and thunder-storms less frequent than in England. As New Zealand is near our antipodes, the seasons are reversed, our summer months being winter months in the Southern Hemisphere. Some little difference of climate is caused by the difference of latitude between the northern and southern colonies; but this is less than might be expected. The mean temperature of the central part of New Zealand, as compared with that of London, is as follows:—New Zealand—spring 56°, summer 66°, autumn 58°, winter 52°; London—spring 49°, summer 62°, autumn 52°, winter 40. (Swainson; Hursthouse.)

Minerals.

From the peculiar geological formation of the country, it is probable that coal, copper, gold, and other metals, will be found in abundance; already accident, rather than scientific research, has discovered that the most important and valuable exist. Coal has been found near the North Cape, on the banks of the Waikato, at Mokau, at Massacre Bay, and in the Canterbury and Otago settlements. Gold-diggings are being worked at Coromandel, near Auckland, and at Aorere, near Nelson; and it is reported that this precious metal has been discovered in the Matoura River in the Otago colony. Copper is found at Kawau, the Great Barrier Island, Monganui, and at the Dun Mountain, near Nelson. Iron, in the form of pyrites and magnetic iron-sand, abounds; the latter especially near New Plymouth, and covers the shores for miles, yielding 50 per cent. of iron of the finest quality. Some of the rocks are powerfully magnetic. Lead and manganese have been met with near Auckland. The purest sulphur is abundant. Alum and nitre are found at Wanganui and near the Rotorua lakes: rock-salt near Mercury Bay. Various useful earths—fire-clay, pipe-clay, ochres, &c.—are common. Slate, marble, granite, sandstone, and freestone, are found in various parts; and limestone exists in many localities, and is of great purity. (Hursthouse.)

Vegetation.

The vegetation of New Zealand is remarkable. Six hundred and fifty distinct species of trees and plants are indigenous, of which scarcely twenty bear even a general resemblance to any of our English plants; there are few annuals and flower-bearing plants, but a large number of tree-creeping parasitical plants, and of the beautiful fern and palm-tree family. The mode of growth in a New Zealand forest is different from anything in the Old World. "Thousands of tall columnar trees, 100 to 200 feet high, struggle up through a wilderness of underwood, their leafy heads so loaded with tufts of rushy parasites, that the true foliage is almost lost, while innumerable creepers coil round every stem, run up every limb, glide from head to head, and entwine the topmost boughs of a dozen trees in fifty Gordian knots. The underwood consists of these creepers, and of an equally dense growth of young saplings mixed with forest shrubs; and such is the closeness of the growth, that sun and air scarcely can penetrate." (Hursthouse.) The Kauri pine supplies splendid spars and masts. Other pines are useful for building purposes, furniture, &c. A resinous gum is an article of export. The root of the fern was formerly the chief vegetable food of the natives; and the *Phormium tenax* furnishes the New Zealand flax, which at some future period may be an important export.

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Animal kingdom.

The quadrupeds of New Zealand, previous to the arrival of Europeans, were the rat and the dog. Pigs were introduced by Captain Cook, and other valuable quadrupeds followed. There are about fifty varieties of land birds, and about a dozen of coast birds, of which the kiwi is the largest. The gigantic moa, 12 feet in height, is probably extinct, unless existing in the western ranges of the middle island. The rivers abound in small fish resembling the eel, grayling, whitebait, &c., of our rivers. The sea fish are numerous, but inferior to those of Europe for culinary purposes. The black whale frequents the coast from June to October. Seals are found in the remote south. Sharks are common on the coast. Cray-fish, oysters, cockles, and mussels are abundant. The insects are similar to those in England. The sand-fly is annoying to travellers in the summer. (Hunburn.) (For the natural history of New Zealand we must refer to the able treatise of the Rev. Robert Taylor, *Teika a Maui*.)

Political geography.—The six colonies.

By the New Zealand Constitution Act (1852), the three islands are divided into six provinces, three of which are in the northern island, viz., Auckland, New Plymouth, and Wellington; the remaining three are in the middle island, viz., Nelson, Canterbury, and Otago. The southern island forms an appendage to the latter colony. Although a very small portion of the island thus geographically appropriated is occupied by the European settlers, this division is a convenient one for the purpose of a more particular description of the present condition of the British colonies in New Zealand.

Auckland.

Auckland, the northern province, is about 400 miles in length, 200 in breadth, with a coast-line of 800 miles, and an area of about 16,000,000 acres. It possesses the only navigable rivers of any importance to be found in the island, namely, the Waikato, with its tributary the Waipa; the Thames; the Piako; the Kaipara, with its tributary the Wairoa; and the Hokianga. There are also several smaller streams, which at their mouths form suitable harbours for ships of from 400 to 500 tons, and are navigable for boats of 20 tons from 7 to 10 miles. Larger harbours are numerous. The Waitemata (upon which Auckland stands), on the east coast, nearly joins the Manukau harbour, on the west coast, from which a narrow isthmus of 6 miles separates it. The Waikato, Kawhia, Whaingaroa, Kaipara, Hokianga, Wangaroa, Bay of Islands, Mercury Bay, Tauranga Bay, Maketu, Hicks Bay, Turanga or Poverty Bay, are also respectable harbours, with others of less note. This very extensive water communication, so important to infant settlements, especially in a country where roads are few, and carriage by land almost impossible without them, has led to the largest amount of European immigrants being

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settled in this part of New Zealand, without any adventitious help from colonizing companies. About one-twelfth of the sixteen millions of acres has been purchased of the natives by the colonial government. The chief town, Auckland, situated on the south side of the Waitemata harbour, and, like another Corinth, commanding the narrow isthmus of Manukau, is one of the finest commercial sites in New Zealand, "the centre of a network of marine highways, a youthful antipodal Venice, surrounded by natural canals." (Hursthouse.) Being built upon hills, there are few level streets; but the houses are generally respectable. The public buildings, churches, chapels, &c., are equal to those in any town of the same size in the mother country. The Church of England and the Wesleyans have respectable schools for the education of the European population, and institutions for the training of the native youth in the vicinity. Two weekly English newspapers are published, and one in the native (Maori) language. The population is about 8000. Near to Auckland are the military pensioner villages of Panmure, Howick, Oneunga, and Otahu, all within a range of 6 or 10 miles, and connected with Auckland by well-made roads. Russell, in the Bay of Islands, which was once intended for the capital, is but a very small town. Besides, there are various coast settlements, such as Coromandel, Otea, Wangari, Wangaroa, Monganui, Hokianga, Whaingaroa, Kawhia, and Tauranga, which have from 50 to 100 pioneer settlers, the nucleus of future city populations. The principal lakes are Rotorua, Tarawera, Rotomahana, and Taupo, in the vicinity of which are found the hot springs, mud volcanoes, &c., to which reference has already been made. In the general fertility of the soil, and in the amount of available land for cultivation, Auckland is fully equal, if not superior, to the other provinces in the northern island, although in the peninsula north of the Waitemata there is much poor and swampy land. The gold field at Coromandel, and the copper-works at the Great Barrier Island and Kawau, are now partially abandoned for want of labour; but the mineral treasures of this province will at some future period contribute largely to its resources. The census of 1855 gave a population of 11,919 Europeans; but the estimate for 1857 is about 15,000, to which we must add 35,000 natives, who contribute their fair share to the industrial resources of the colony.

New Plymouth.

New Plymouth, called also *Taranaki*, is the smallest of the six provinces, and is situated on the west coast, between Auckland and Wellington. It has a coast-line of 150 miles, and is about 100 miles long by 50 broad, with an area of about 3,000,000 acres, of which not quite a fiftieth part is yet in the possession of the colonists. It has no navigable rivers, but many small streams, as the Mokau, Oneiro, Waitera, Manawapo, and Patea, which are occasionally entered by small vessels. The roadstead near the town of New Plymouth affords great facilities for the loading and unloading of the largest vessels, and there is no doubt but that by the outlay of a moderate sum of money a good harbour might be formed at this place, for which there are peculiar natural facilities. Around the town, or rather township, of New Plymouth, the European population is mainly concentrated within a radius of 10 miles. The soil is peculiarly fertile; so that this portion of the island is by common consent termed the "Garden of New Zealand." The country near the sea is open and undulating; beyond, at some distance, it is forest, containing excellent timber. Mount Egmont, covered with perpetual snow, gives a peculiar character to the scenery. The unwillingness of the natives to sell their lands has hitherto retarded the progress of this settlement, by preventing a larger accession of immigrants. In 1855 the European population was 2113, and the estimate for 1857 was 3000. This small community, intellectually and morally, is perhaps one of the most select and respectable in the world—not even excepting the most favoured portions of the mother country. The native population is about 8000. One weekly paper is published. When the colonial funds admit of the expense requisite for the formation of a harbour, and when the native title has been more extensively extinguished by purchase, this portion of New Zealand will offer irresistible attractions to settlers from the mother country.

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Wellington.

Wellington is the southern province of the northern island, 200 miles long, 100 broad, with a coast-line of 500 miles, and an area of 12,000,000 acres, of which about one-third has been purchased of the natives for the purpose of European settlement. The land near and within 20 miles of the principal harbour (Port Nicholson) is mostly mountainous, densely timbered, broken by steep ravines, and most unfit for cultivation; but the valleys of the Hutt, Wairarapa, Wanganui, Rangatiki, Manawatu, and sundry adjacent portions, are admirably adapted for agricultural purposes. The vicinity of Hawkes Bay (Ahuriri) has also much good land; and from this point there is a communication across the island to Manawatu, and southerly to the Wairarapa valley. Three of the rivers may be called semi-navigable, as they may be entered by vessels of small tonnage—the Wanganui, the Rangatiki, and Manawatu. The harbour of Porirua is available for small vessels, and this harbour and the available country to the north, in the basins of the Manawatu, Rangatiki, and Wanganui rivers, are connected with the town of Wellington (Port Nicholson) and the Hutt River district by an excellent road, which winds round the spurs of the Tarirua range. A good road along the bay connects Wellington with the Hutt River valley; and another road now forming will lay open the whole of the Wairarapa valley, and afford easy means of intercourse with the capital. In no part of New Zealand has so much been done to overcome formidable natural obstacles by means of good roads. Wellington, the capital, is situated on a beautiful bay opening into Cook's Straits, which forms the harbour of Port Nicholson, and which is 6 miles across, surrounded by hills of great elevation, and affording a shelter for large vessels. The town, built mainly of wood, stands on two level spaces on the west and south sides of the harbour, and rises in terraces from the margin of the bay, which gives it a most picturesque appearance from the sea. The bay and scenery around has been compared to that of Naples. Occasional earthquakes, which have, however, ceased to be dreaded since the houses have been built of wood, and high winds, are the main drawbacks to this locality. Its central position on the great marine highway of Cook's Straits is the greatest advantage of Wellington, which must secure for it an important rank among the future depôts of New Zealand; especially as it possesses, next to Auckland, the best portion of the northern island. Its population in 1857 was probably 5000. The other townships are, a rural settlement in the Hutt valley, a small town at Wanganui, Port Napier at Ahuriri (Hawkes Bay), and the native mission village of the Church of England at Otaki, remarkable for its beautiful church, of native workmanship. The province probably contains 12,000 Europeans and 15,000 native inhabitants. Two weekly papers are published at Wellington.

Nelson.

Nelson is the northern province of the middle island, and is 150 miles long, 140 broad (with a coast-line of 500 miles), and an estimated area of 15,000,000 acres, all of which are virtually open for settlement, as the native population scarcely amounts to 1000. The climate is comparatively serene and dry, and more equable than in any of the other provinces. It possesses great mineral wealth in coal, copper, and gold. Between D'Urville Island and Cloudy Bay are a large number of noble harbours opening into Cook's Straits, of which Queen Charlotte's Sound and Pelorus Bay are the principal; but the wooded hills rise so abruptly that it has been stated, though perhaps with some

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exaggeration, that there is scarcely a thousand acres of land fit for the plough to be found along their margins. The valleys of the Waimea and Motueka, of Blind Bay, Massacre Bay, and Cloudy Bay (Wairau), afford, however, ample room for the agriculturist and grazier. The Grey and Butter rivers, on the west coast, are now found to be available as ports, and to possess in their vicinity much valuable land—a pleasing exception to the general disparaging character which has been given to the capabilities of the west coast of the middle island. Nelson, the only town, is situated at the bottom of Blind Bay, and possesses a small but safe harbour, 50 miles away from the turbulent winds of Cook's Straits. It is sheltered by a range of hills from the southern blasts, and enjoys a climate equable and serene beyond any other locality. The Dun Mountain, within a mile of Nelson, contains treasures of copper yet to be developed. The European population of the colony, which amounted in 1855 to about 6000, and which was supposed to be, in 1857, 9000, is mainly located around Nelson, or within a moderate distance. There is a weekly paper published at Nelson. A new township has been formed at the harbour of Waitohi or Newton Bay, a south-eastern branch of Queen Charlotte's Sound; this is intended to be a port for the produce of Wairau (Cloudy Bay), and of the Awatere plains, to which district a road is now being formed of 12 miles through a nearly level valley. Other paths are being discovered through the mountain-passes, by means of which communication will be facilitated with the various settlements in the Nelson province, and with those in the adjacent province of Canterbury. Two lakes are connected with the Butter River (Rotorua and Rotuiti); but as yet the interior of the middle island has not been explored. The gold-diggings at Aorere (Motueka River) are now exciting much attention, from their productiveness; but their main value to this province will be the additional incentive given to emigration to it.

Canterbury.

Canterbury is the central province of the middle island, and is 200 miles long by 100 broad, with a coast-line of 500 miles, and an area of about 14,000,000 acres, all of which are available for settlement, as the native population is not above 500. The western portion of this province is probably rugged and scarcely accessible; the centre is occupied by mountainous ranges not yet explored. A vast elevated plain of 4,000,000 acres extends from the foot of these central ranges, gradually descending 40 miles to the heights above Port Victoria (called also Port Cooper). This plain is watered by more than twenty rivers. The portion nearest the west coast consists of a deep border of fine cattle-grazing and loamy agricultural land; but the great inland portion is a true pastoral country, covered with a perpetual herbage of grasses and dwarf shrubs, and admirably suited for the breeding and depasturage of sheep, horses, and cattle. The absence of wood is remarkable, but there is plenty in Banks' Peninsula and at the foot of the central highlands. About fifty small rivers discharge themselves into the sea on the east coast of this province, of which the mouths of the Ashley, Courtney, and Avon are navigable for a short distance by very small boats. A remarkable feature in this province is Banks' Peninsula, which protrudes from the east coast, and consists of a pile of densely-wooded volcanic hills, among which the principal harbours of the colony are found,—viz., Port Victoria (or Cooper), Port Levy, Pigeon Bay, and Akaroa Harbour. Lyttleton, the post-town of the colony, is situated upon Port Victoria, at the foot of the heights which lead to the great plain. Population from 2000 to 3000. A good road is being made up the heights, to connect Lyttleton with Christchurch, the capital, which stands on the Avon, on the border of the great plain. Population between 2000 and 3000. There are small settlements on the other harbours of the peninsula. Akaroa was the site of the French settlement formed in 1840, and yet retains many of its original settlers. This colony was originally designed for members of the Church of England, and possesses a large number of the clergy of that church, and educational institutions conducted by them. There are also Wesleyan and Presbyterian churches, as the exclusive principle has been wisely abandoned. Great facilities are offered to small farmers and graziers, and the tide of emigration is rapidly flowing in this direction. The European population in 1857 was supposed to be not less than 7000, who, as a matter of course, have their weekly journal.

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Otago.

Otago is the southern province of the middle island, and includes the whole of the southern or Stewart's Island. It is 150 miles long, 200 broad (with a coast-line of 500 miles), and an area (including Stewart's Island) of about 18,000,000 acres, the whole of which is available for settlement, as the natives do not exceed 500 in number. The south-western coast is remarkable for its thirteen harbours, like so many breaches in the sea-wall of this otherwise iron-bound coast, and which run in a N.N.E. and S.S.W. direction from six to twenty miles inland. The land around these harbours rises almost perpendicularly from the water's edge, and is covered with trees suitable for all purposes. The depth of water also is remarkable, as soundings can rarely be obtained under from 80 to 100 fathoms. The ports on the east coast are Moerangi, Otago, and Molyneux Bay. Stewart's Island is well wooded, contains many excellent harbours, of which Port Pegasus is the principal, and is partially colonized by various little communities of tens and twenties of old whalers, half-castes, and natives. The European population of the province, about 4000, chiefly Scotch, is settled on the east coast, in or near the following settlements:—Dunedin, the capital, stands at the head of an arm of the sea, which is only navigable for large ships as far as Port Chalmers; population about 2000. Port Chalmers is a rising seaport. Invercargill, the most recent settlement, is situated on the Bluff in Foveaux Straits, in a central position between the Bluff harbour and the New River, a fine stream, navigable for 20 miles. The lofty mountain ranges towards the west coast, and the three large lakes which are reported to exist in the interior, have not yet been explored. From these ranges to the sea-coast on the east the province consists for the most part of splendid plains diversified with hill and dale, as if to suit our notions of beauty, and available for all grazing and agricultural purposes. The climate is bracing and invigorating, yet temperate. This important province has the advantage of being a few days nearer England than any other part of New Zealand. Dunedin has, like the other colonial capitals, its weekly journal. It was originally the settlement of the Free Church of Scotland, and complaints are made of the somewhat exclusive tone of feeling prevalent in society, which is annoying to settlers from other countries and belonging to other churches; but this grievance, if it does exist at all, must vanish with the increase and spread of the population, while the industry, moral worth, and enterprise of the Scottish population must insure for this colony a high place among the political communities of New Zealand.

Emigration field.

It will be seen from the above sketch of the various colonies, that while there is ample room in the northern island for emigrants, the whole of the middle and southern islands are open for settlement, without any possible interference with native rights. And when we consider the climate, soil, harbours, and other available capabilities of these invaluable islands, which only require a large European population for their speedy and full development, we cannot but augur favourably as to the position which New Zealand will at some future period occupy in the history of the world.

The population of European race in New Zealand is

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Statistics, population, &c.

estimated by Hursthouse, for the year 1857, at 50,000, which is perhaps somewhat beyond the actual number; add to these 60,000 natives, and the entire population will be found not to exceed 100,000,—a scanty supply for a land which is as capable as the British Islands of supporting nearly thirty millions of people in all the comfort and luxury of civilized life.

Districts.	Europeans.	Natives.	Acres cultivated.	Sheep.	Cattle.	Horses.	Pigs.
Auckland.....	15,000	35,000	50,000	50,000	20,000	2,800	7,000
New Plymouth	3,000	8,000	15,000	30,000	6,000	500	3,000
Wellington.....	12,000	15,000	50,000	350,000	23,000	2,200	7,000
Nelson.....	9,000	1,000	50,000	330,000	17,000	2,000	7,000
Canterbury ..	7,000	500	20,000	320,000	16,000	1,600	6,000
Otago	4,000	500	15,000	120,000	12,000	1,200	3,000
Native population...	...	...	25,000	...	6,000	1,700	67,000
Total.....	50,000	60,000	225,000	1,200,000	100,000	12,000	100,000

Trade, marine.

The exports of the New Zealand colonies consist of provisions and timber to the neighbouring Australian colonies, and of wool, tallow, spars, flax, gums, copper ore, &c., to the mother country. The estimated value of these exports for 1857 is L.400,000, while the imports may be calculated at L.600,000; part of the latter consisting of property belonging to emigrants from Europe, and forming part of their capital stock. The welfare of New Zealand depends mainly upon agricultural pursuits, as whaling stations have ceased to be profitable, and the copper mines have not succeeded, from the scarcity of labour. A taste for maritime pursuits seems to be rapidly developing, if we may judge from the statistics of the shipping the property of New Zealand, as well as that employed in the foreign trade. About 700 vessels of all sizes belong to the colonists, the tonnage of which is 20,000, and most of them are of colonial build. The foreign trade employs 400 vessels, with a tonnage of 250,000. Steam communication is maintained between Sydney and Auckland, and subordinate lines are soon to ply between Auckland and the principal ports of the islands. The adoption of the Panama route for the Australian mail service to and from England would bring New Zealand within forty days of the mother country.

The value of land varies in every colony, but the minimum price of wild land may be stated as ranging from 5s. to 60s. the acre. Large tracts of land, especially in the middle island, may be occupied, at fixed moderate rents, for grazing purposes.

Political government.

The present constitution of New Zealand, adopted by Sir J. Pakington, the colonial secretary under Earl Derby's administration, received the sanction of the British Parliament in the session of 1852. A plan of government, on the principle of double election, framed by Earl Grey, the colonial secretary of a previous administration, had met with almost universal disapprobation, and had been withdrawn without having had a trial. The main provisions of the plan of government now in operation are as follows:—

(1.) The six provinces were formed into distinct corporate bodies, with privileges far beyond those enjoyed by ordinary municipalities; so that the term "government" may be with propriety applied to them. Each of these was empowered to elect a superintendent and provincial council, the latter not to consist of fewer than nine members, but capable of being enlarged at the discretion of the governor-general. The superintendent and council are elected for a period of four years, by a suffrage which is almost universal, the qualifications being small, and the possession of property being a common thing in new colonies. The governor-general may disallow the election of any superintendent, and may dissolve the provincial council at pleasure, and may also disallow any bill passed by them within three months; but if allowed by him, it cannot be annulled by the imperial government in England. The superintendent may summon and prorogue his council; but there must be one session at least in each year. These provincial councils are prohibited from interfering with general legislation affecting the whole colony; as the customs, civil or common law, currency, weights and measures, post-office, bankruptcy, lighthouses, harbour dues, marriage, inheritance, &c.

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(2.) The government of the whole colony of New Zealand to be vested in a governor appointed by the crown, with a moderate civil list, secured by act of Parliament; and also in a General Assembly, consisting of a Legislative Council and House of Representatives, meeting in annual session in Auckland and legislating for the entire colony, with the exception of matters of purely local interest, which are left to the provincial councils. The Legislative Council consists at present of 15 members, nominated for life by the governor. The House of Representatives consists of 36 members elected for five years, by a suffrage similar to that of the electors of the provincial councils. The House can be dismissed by the governor at pleasure.

(3.) In the general government, and also in the provincial superintendencies, the principles of responsible government are carried out as in England. The majorities create and turn out administrations, and each acceptance of office by a member is followed by a necessity of a re-election.

(4.) To avoid the interference of the British Colonial Office in the land question, the control of the public lands in each province has been since vested by the General Assembly in the respective provincial councils; the legislation of which minor bodies, if confirmed by the governor-general, is not liable to be disallowed by the government in England. This appears to be a palpable evasion of the plain meaning of the act of Parliament by which the new constitution was established in New Zealand.

Making due allowance for the natural and inevitable difficulties attendant upon the introduction of a new system of government into a new country, and among a scattered population, it must be admitted that the constitution (cumbrous and complex as it may appear for a population which, in 1853, scarcely exceeded 30,000, and which now, in 1857, does not amount to 50,000) on the whole works well. Local self-government is so desirable for young colonies, that any inconvenience and cost is a small price for the inhabitants to pay for the privilege of developing their own resources and managing their own affairs, unchecked by a distant executive and legislature, necessarily ill acquainted with their wants and capabilities. These provincial assemblies and administrations have called forth much local patriotism, and have developed much administrative talent; and it must be remarked that the colonists of New Zealand are, a large proportion of them, from the more educated and respectable classes of the mother country. A time may come when increased facilities of communication may render it desirable to consolidate the local superintendencies, and merge their powers in that of the general government; but this and other changes may be left to the colonists themselves, who are the best judges of their own legislative necessities.

Revenue and expenditure.

It is difficult to ascertain the exact amount of the annual revenue and expenditure of the seven exchequers of New Zealand (viz., the six colonies and the general government). Hursthouse gives the expenditure and revenue of 1856 at L.270,000; one-half of the expenditure being for purchase of land and public works. The revenue for 1857 arising from land sales, customs, &c., is estimated by the same writer at L.300,000. A loan of L.500,000 has been guaranteed by the British Parliament for New Zealand, to enable the general government to pay off the debt claimed by the New Zealand Company, and for emigration and other purposes. The government claim the right of pre-emption in the case of land, so that no land can be sold by natives except to the crown; this land is sold again at a much higher price to the European settler. It is questioned

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whether this mode of purchase has not been on the whole injurious, as the natives are becoming more and more unwilling to part with land in large portions, but would be ready to sell in small parcels to individual purchasers.

The Maori (native) population.

Some account of the native population will be found in the article AUSTRALASIA, section viii., vol. iv. We may here add some further information respecting this interesting people, now rapidly progressing from savage life into civilization. It is obvious that the Maori belongs physically, and by the structure of his language, to the light-coloured race of the Pacific Ocean, which is found spread over the islands for a distance of 6000 miles (from the Sandwich Islands to New Zealand). This race is supposed to be of Malayan origin by some; while others suppose the ancient Mexicans to have been the parent stock of the Pacific islanders. We require a more perfect acquaintance with the languages of the Eastern Archipelago in order to arrive at any definite conclusion respecting the ethnology of this part of the world. Certain it is that the progenitors of the Maori came from Hawaii and Tanai, two of the Sandwich Islands, called in the New Zealand dialect Hawaiki and Tawai, about 500 years ago. The names of thirteen canoes of the leading chiefs, and of the articles brought in each canoe have been preserved, with the additional information, that the emigration came by the way of Tahiti and Easter Island (Waiho). "The New Zealanders are decidedly a mixed race: some have woolly hair, others brown or flaxen; some are many shades darker than others. The peculiar features of the Tartar are also very common; the oblique eye, the yellow countenance, the remarkable depression of the space between the eyes, so that there is no rise in the nose, seem clearly to indicate that some portion of the race is of Chinese or Japanese descent." (Taylor.) This view is confirmed by the fact of a bell, with characters similar to Japanese, being found in the district of Wangaree in 1839. It is supposed that, as a race, the Maori have degenerated from their ancestors, who, at Easter Island, have left monuments of bygone skill in the arts, and who, up to the discovery of the islands by Captain Cook, possessed double canoes of superior build to any now found among them. The superior houses of the Maori, and the art of weaving, may have been introduced by these Chinese or Japanese emigrants accidentally thrown upon their coasts. Native traditions, mixed up with much fable, seem to indicate the existence of an aboriginal population, which was either destroyed or amalgamated with the Maori emigrants. It is remarkable that, like most colonists, while preserving the religious traditions of their ancestors, the political bond of union was broken among themselves. Split into innumerable families and tribes, each having its own head, and independent of the rest, the history of the Maori is one of discord, war, and blood. It is reported that once a large temple called the Whare-Kura existed, in which all the tribes met for worship, for council, and for the settlement of disputes. This sacred locality, at first a grand place of union, became the source of discord; the chiefs quarrelled, fought, and at last burnt the building; and from that period there has been no union; one tribe has ever been opposed to the other. At present Taylor enumerates twenty-three principal tribes yet intact, besides fragments of others nearly extinct. The power of the chiefs rests upon their birth and personal character. No great chief, like those found in the Polynesian islands, exercises regal power. By the Tapu, which is a powerful engine of control possessed by the chiefs in New Zealand, as well as in the other islands of the Pacific, the common people were effectually restrained, sometimes for good, and also for evil. It consisted in making any person, place, or thing sacred for a longer or shorter period, and was in fact a religious observance established for political purposes. (Taylor.) With a philosophical cosmogony and a poetical mythology, they had no knowledge of a Supreme Being, but believed in a multitude of divine beings, the creators of various natural objects; and these were confused and mixed up with the spirits of their ancestors. Thus, like the Greek heroes of the mythical period, most distinguished persons among the Maori trace up their ancestry to a deity (Atua). One of these (Maui) is said to have fished up New Zealand (the universal tradition of the Polynesian races in reference to their several islands). Prayer, in our sense of the term, formed no part of the religion of the people: the *karakia*, which we translate "prayer," is rather a spell or incantation to compel the gods to be obedient to their wishes. These were accompanied by sacrifices and offerings. Image-worship was confined to one locality, and was offered to the deity, who was supposed to be present in the idol. The high chiefs (*Ariki*) and priests (*Tohunga*) were supposed at all times to be able to hold visible intercourse with the gods. The belief in the power of bewitching, as being possessed by every one, was universal, and kept the native mind in bondage. Great attention was paid to the burial of the dead, for the sake of the spirit which survived the dissolution of the body. "The prevailing idea of the abode of spirits was, that they went to the Reinga, which is another name for Po or Hades: the word Reinga literally means a "leaping place." The spirits were supposed to travel to the North Cape, or land's end, and there, passing along a long, narrow ledge of rock, they leaped down upon a flat stone, and thence slinging themselves into the water by some long sea-weed, they entered Po, the Reinga being the passage to it. It was supposed that there were several compartments in Hades, the lowest being the worst, having no light or food, and there the spirits were thought gradually to pine away, and to be finally annihilated." (Taylor.)

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Before the general reception of Christianity the natives resided in large fortified stockades, commonly erected on the summit of a steep hill, or on a peninsula, &c.: these are called *pahs*. The strong high fence of these *pahs* presents no mean obstacle to foes not possessed of artillery. Within the *pah* are numerous subdivisions and lower fencings, communicating with each other by means of stiles: in each court a house, cart-house, and store for food: the houses partly sunk in the ground, with a gable roof, and a portico or verandah, where the occupants generally sit. The post in the middle of the house, which supports the ridge-pole, has its lower part carved into the form of a human figure representing the founder of the family; and the same figure is generally found to surmount the gable end of the house. The inner chamber or sleeping-place is heated like an oven, and is offensively so for Europeans; but the natives enjoy it the more, being huddled together almost naked for the whole night. Now the *pahs* are generally deserted, especially those in inconvenient positions; the stockades are left to waste away; and the population is found in villages and solitary farms, as in our own country. Slavery scarcely exists now, having yielded to the power of Christianity; though the social distinction yet subsists, as it does even in more civilized communities. The pride of birth is found in perfection in New Zealand, for "very little is thought of a chief who cannot count back some twenty or thirty generations, and the high families carry theirs back even to the beginning of all things. I was once very much amused, in obtaining a tradition of this kind, beginning with '*from the nothing the something*,' which went on gradually introducing name after name, and at last terminating with that of the speaker." (Taylor.) To assist the memory, each family has a carved board, which serves as a sort of genealogical table, and the children were from this taught the names of their ancestors. Polygamy, especially among the chiefs, was common before the conversion of the natives to Christianity. Infanticide was not unusual, and there was a great want of natural affection, with much show of it, if we may judge of the ceremonious salutations—the nose-rubbing, and the *tangi*, or weeping. War was carried on most barbarously; the defeated party, if not slain, were reduced to slavery. Cannibalism was universal, but was said to be but of recent origin, and arose, not from hunger, but from a deep feeling of revenge. Now the very mention of this horrid custom is hateful to the Maori; such a change has Christianity effected in public opinion, as well as in national usages, within the space of one short generation. A large number of songs, proverbs, and fables are known to the old men, and formed the oral literature of the people before the missionaries introduced letters and a new order of ideas. These have been preserved by Sir George Grey and by the Rev. Richard Taylor, just in time, as in another generation they would have been lost. The native dress, made of the flax plant, and the practice of tatooing, and many other peculiarities of the preceding generation, are now rapidly passing away; and future travellers will not be able to recognise the Maori described in the writings of visitants of twenty or thirty years ago. The land tenure of the Maori people throws some light upon their economical condition while comparatively savage and uninfluenced by European civilization, and is also of importance in its bearings upon the future relationships of our colonial government with the native tribes. No one has so fully and satisfactorily described these as the Rev. Richard Taylor:—"Land is held in three ways by the natives: either by the entire tribe, by some family of it, or by a single individual. The common rights of a tribe are often very extensive. These generally apply to waste lands or forests, and convey to each individual of the tribe the right of hunting and fishing over those parts. By intermarriages several tribes are sometimes thus entitled; but if such land be sold, it is nominally said to belong to the principal chief or chiefs of the tribe; they are the parties with whom the treaty is made, and to them the payment is given, which is, however, a nominal honour, the money being equitably divided amongst all who are entitled to a portion, the seller rarely retaining anything for himself. The same may be said of that which is claimed by families: private rights to land are very rare. The eel-cuts are held in the same way. These are drains made from lakes or swamps, with weirs at the outlet to catch the fish, which flow out in great quantities during the floods."

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It appears that all the descendants of the first possessor of a piece of land or eel-cut possess a claim to a share of the property, and that the stones placed as landmarks are as sacred as the *dii termini* of the ancient Romans. The property of the native tribes in their lands having been acknowledged and strictly respected by the British government, the existence of the Maori is secured from the degradation which has befallen the natives of many of our colonial possessions. Yet for some time after the commencement of regular intercourse with Europeans, the population rapidly declined, owing, perhaps, in some measure, though not entirely, to the introduction of European diseases, and the evils attending the transition state of the population from their previous habits to those of Europeans. For instance, the warm flax dress, impervious to the rain, was abandoned for the shirt and habiliments of the Europeans. This mode of dress—worn in all weathers, and by night as well as by day, without a change, and when wet, dried upon the body of the wearer—was followed by a great increase in consumptive complaints: add to this the introduction of fire-arms, which was at first attended with a large increase in the number slaughtered in war, as their possession was confined to a few tribes who took advantage to revenge themselves upon their enemies. At present there is a great disparity in the number of the sexes,—the women being few in number compared with the men; and the children are yet fewer in proportion, say 75 females and 45 children to every 100 adult males. We suspect that this diminution of population is incident to savage tribes on coming in contact with a more civilized people, and that after a time this diminution may cease, and a gradual increase take place. Indeed, it is the opinion of intelligent missionaries that the population is beginning to increase, and that in some parts of New Zealand—Taranaki, for instance—the number of births already exceeds the number of deaths.

Missionary labours.

The present advanced condition of the Maori population is owing mainly to the indefatigable and praiseworthy exertions of the missionaries. The Rev. Samuel Marsden, the colonial chaplain in New South Wales, established the first mission of the Church of England in New Zealand in December 1814; and in 1821 the first Wesleyan mission station was founded by the Rev. Samuel Leigh. For many years the field appeared the most unpromising, and no impression appeared to be made upon the native mind; but at last complete success has followed the efforts made, and now all the inhabitants of New Zealand are nominally Christian. Cannibalism, polygamy, slavery, and other abominations of heathenism have disappeared. Life and property are perhaps as safe in New Zealand as in any country in the world. The missionaries have introduced the plough and all the useful arts of civilized life; they have reduced the language to writing, compiled grammars and dictionaries, and translated the Word of God and other works into the language of the Maori population, most of whom can now read and write. The progress of the natives in civilization has far surpassed the most sanguine anticipations of those who are competent to estimate the obstacles which have to be overcome in the transition of a whole people from savage customs to the decencies and comforts of civilized life. As agriculturists and traders, the Maori people occupy respectable positions; some of their farms are highly creditable to them; and in bargain-making they manifest something of the caution and shrewdness of the Scottish character. Many of the chiefs are owners of steam flour-mills, and others possess small trading-vessels; some are shareholders in colonial banks; and many, both of the chiefs and people, after selling portions of their land to the colonial government, have shown their appreciation of the security of an English title, and their faith in the additional value which will be given to it by European industry, by becoming purchasers of allotments for their own use. In addition to the European missionaries who labour among them, almost every village has its native teacher and common school; and there is an institution for training native teachers at Turanga. Among the special friends of the Maori race we may mention the late governor, Sir George Grey, and that remarkable man, Bishop Selwyn. The Wesleyans have an institution at the "Three Kings," near Auckland, for the training of Maori youths, which deservedly stands high, and, together with other kindred institutions, is exerting an important influence upon the more respectable class of the native population. There are other missions of minor importance carried on by the Roman Catholics and by a German society.

The future of the Maori population.

The future of the Maori population is contemplated by philanthropists with intense interest. If the legislation of the British colonies of New Zealand be in keeping with the general character of the colonists, and of the religion which they profess, the Maori will, in one or two generations, become thoroughly identified in interests, views, and feelings with the English population. It is, however, very desirable that means should be adopted at once to give the chiefs and more respectable wealthy and educated natives a definite political and social position in connection with the local and general legislatures. Much uneasiness is already felt by the more intelligent natives at the fact of their political nothingness; and one very large meeting was held last year (1857) to consider the propriety of electing a king as the representative of the Maori people. This proposal has for the present been negatived; but the feeling which prompted it remains, and must be grappled with. The Rev. Robert Taylor, an experienced missionary, and Charles Hursthouse, Esq., a well-known colonist and writer on New Zealand, contemplating this difficulty from very different points of view, agree in recommending that a certain number of the high chiefs should have seats in the General Assembly, and that they should be placed in the magistracy of their respective districts, with suitable salaries. We have no doubt that in all questions affecting the local interests of their respective districts and people, they would be valuable senators, legislators, and magistrates. It is gratifying to know that the feeling among the European population of New Zealand towards the aborigines is most friendly; and no plans are so popular, or meet with more general support, than those which have the advancement of native interests for their object.

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History of European intercourse and colonization.

The history of the discovery of these islands, and of European intercourse up to the year 1809, will be found in the article AUSTRALASIA, § viii., vol. iv. The increase of the whale fishery in the South Pacific Ocean led to the settlement of numerous deserters from whale ships in various parts of New Zealand. This was followed by the establishment of whaling stations on the shores, which afforded opportunities for the introduction of many of the less reputable of the convict class from New South Wales. In the wake of these followed many reputable traders and settlers engaged in the timber trade, &c. A large European population was thus planted principally in the northern part of the northern island, uncontrolled by any legitimate authority, and amenable to no law. Besides these irregular settlements, there were a number of mission villages belonging to the Church of England and the Wesleyan missionary societies, exercising a measure of influence upon the natives and more respectable Europeans, and occasionally brought into trying circumstances through the conduct of the lawless portion of the European population, as well as from the violence and cupidity of the natives. The measures adopted at intervals by the imperial government, and by the colonial government of New South Wales, were not only partial and calculated rather to irritate than repress crime, but proceeded on assumptions of a contradictory character as to the right of interference, which afterwards caused much embarrassment to these authorities when compelled to take more decisive action. By the acknowledgment of the independence of the native chiefs in 1831, and again in 1835, and by the appointment of Mr Busby as consul and British resident, but with no means at his disposal to maintain his authority, the British government endeavoured to meet the necessities of the case, and to throw obstacles in the way of colonization. Other views influenced a large class of merchants and gentry in Great Britain; and the New Zealand Company was formed in 1837, which, in the year 1839, received a charter, and immediately proceeded to send out colonists to New Zealand. This movement obliged the British government to establish its authority in the islands; and in order to this, Captain Hobson was sent out in August 1839 as consul. The missionaries and respectable Europeans at once rallied around a legitimate authority; and in February 1840 a large council was held at Waitangi, when all the chiefs of that part of the island agreed to acknowledge the Queen's supremacy—"giving up," as they said, "the shadow of the land, but retaining the substance." A second council was held at Hokianga, with similar results; and then Captain Hobson, as lieutenant-governor, proclaimed the British sovereignty over the Isles of New Zealand, 21st May 1840. The seat of government was at first established at Russell, in the Bay of Islands, but in 1841 was removed to Auckland, the present capital; and on the 3d May 1841 the colony was relieved from all dependence upon New South Wales. Meanwhile, a French expedition, sent to occupy Banks' Peninsula, in the middle island, was forestalled by Captain Stanley, who had pro-

Ney. ceeded there a few days previously, and had planted the British flag. The New Zealand Company, which, by taking measures to colonize direct from England, had compelled the assumption of British sovereignty, planted its first settlements at Wellington, in Port Nicholson, and at Nelson in 1839; the year following, Wanganui and New Plymouth were established. The difficulty in obtaining possession and satisfactory title to land purchased by them from the natives, and dissensions with the new government of New Zealand, retarded the progress of these infant settlements, and involved many respectable colonists in ruin. Some untoward events were attendant upon this rapid influx of emigrants. In 1843 a fatal affray occurred at Wairau (in the middle island), in which a large party of European gentlemen were murdered in a dispute with certain natives respecting property in land. Two years after, the chief Heki raised the standard of rebellion in the northern island, and burned the town of Russell; and in 1846 there were disturbances in the Hutt River district. In 1847 there were petty disturbances in Wanganui, since the suppression of which there has been peace in New Zealand with the native tribes. The example of the New Zealand Company was followed by an association of gentlemen connected with the Church of England, who, in 1848, formed the Canterbury settlement; and the same year the Otago settlement was planted by gentlemen in connection with the Free Church of Scotland. No other colonies separate and distinct from these six have been established in the islands. The proceedings of the New Zealand Company provoked much animadversion and controversy both in England and in the colonies which they had originated; but to enter into the discussion of the merits of the case would require more space than can be afforded to this article, and, besides, would lead to no profitable result. The company was finally broken up in 1851, and its debt of L.200,000 has been thrown upon the land revenue of the New Zealand colony, much to the annoyance of the people of Auckland, whose province was beyond the sphere of the Company's operations. In order to reconcile the colony to this burden, a loan of L.500,000 has been guaranteed by the imperial government for the purpose of local improvements, &c. (W. B. B.)

NEY, MICHEL, a marshal and peer of France, was born at Sarrelouis on the 17th of January 1769. His father had been a soldier, but after the Seven Years' War had retired to his native village, where he exercised the humble trade of a cooper. Young Ney had received his education at a school kept by the monks of St Augustin, under whom he appears to have made considerable progress in his studies; but being fired with military ardour by the recitals of his father, he early enlisted, in 1787, in a regiment of hussars, where he served for some time, and was a subaltern at the commencement of the Revolution. He then attained the rank of captain, in which capacity he made his first campaigns, acting as aide-de-camp to General de Lamarche, and afterwards as adjutant-general under the orders of Kléber. This latter employment afforded him several opportunities of distinguishing himself; and he was commonly known by the well-merited surname of "Indefatigable" bestowed on him by his admiring general. In the official reports of the time honourable mention is made of him at the passage of the Lhan in 1795, and also at the combats of Neuwied, Altenkirchen, Montabaur, and Würtzburg. On the 8th of August 1796 he took Pfortzheim, and was promoted to the rank of brigadier-general. In the campaign of 1797 he was again successful; but his horse having been killed at the combat of Steimberg, he fell into the hands of the enemy. Hoche, who admired his undaunted courage, earnestly solicited his exchange, and, as soon as he had obtained it, appointed him general of division. It was in this capacity that, in 1798, Ney commanded the cavalry of the army which, under the orders of Schaumbourg, executed the invasion of Switzerland. On this occasion he acted towards the inhabitants with as much generosity as circumstances would permit; and the following year he acquired a great reputation under Massena, particularly at the battle of Zurich. In the year 1800 he served with the army of Moreau, and greatly distinguished himself both at Moeskirch and at Hohenlinden. After the peace of Luneville he returned to Paris, and was received with great distinction by Napoleon, who found him a wife in the person of Mademoiselle Augnié, a friend of Hortense Beauharnais. When Bonaparte wished to effect the entire subjugation of Switzerland, Ney was sent into that country with the title of minister plenipotentiary, and there seems to have won for himself the golden opinions of the people and the esteem of his master. In 1804 he obtained the baton of marshal of the empire; and the distinguished part which he played in the storming of Elchingen, on October 4, 1805, induced Napoleon, who was an eye-witness of his impetuous daring, afterwards to honour him with the rank and title of Duke of Elchingen. After the capitulation of Ulm, being ordered to occupy the Tyrol, he entered Innspruck on the 7th of November, at the head of the sixth corps of the grand army, which he also commanded the following year in the contest with Prussia. Having contributed essentially to the victory of Jena, he appeared before Magdeburg, and, by a prodigy which still remains inexplicable, he, on the 11th of November 1806, in less than twenty-four hours, received the capitulation of that redoubtable fortress, made 23,000 prisoners, and took 800 pieces of cannon. In the beginning of 1807 he obtained a signal success before Thorn, where the whole Russian army had advanced to attack him, hoping to surprise him in his winter quarters; and, at a later period, he carried the town of Friedland at the battle of that name, which terminated the war in the north of Europe. But the war in which Napoleon found himself involved, if extinguished at one point, was assiduously kept alive at others. Scarcely had he concluded a peace with the Russians at Tilsit, when he hurried away to attack the Spaniards; and Marshal Ney, with his corps d'armée, was transported from the banks of the Niemen to those of the Ebro and the Tagus. The marshal, finding himself obliged to carry on a war of posts and of chicane in Galicia, lost a great number of men in this inglorious service, and with difficulty maintained his ground till the moment when he received orders to unite his corps with that of Massena, who had been sent in order to expel the English from Portugal. But this was found to be impracticable. It was judged that the lines of Torres Vedras could not be attacked with any prospect of success; and when Massena found himself constrained to retire before the Duke of Wellington, Ney commanded his rearguard, and in that difficult retreat displayed equal talent and courage. In 1812 he was recalled by Napoleon to assist in the approaching invasion of Russia, for which an army of more than four hundred thousand men had been assembled on the Vistula. At the terrible battle of Mojaïsk or Borodino Ney commanded the centre; and it was on this occasion, amid the carnage of a conflict unequalled in modern times, that "the bravest of the brave," as Ney was called by the army, earned the title of Prince of Moskwa. Nor did he display less valour and firmness in the disastrous retreat from Moscow, in which his corps almost entirely perished. Napoleon, in one of the bulletins of the army, designated him as having a soul tempered with steel. In 1813 Ney participated in the indecisive victories of Lützen and Bautzen; but he had the misfortune to lose the battle of Dennevitz, where he was defeated by Bernadotte and Bulow, with the loss of 13,000 men, 43 pieces of cannon, and 3 standards. This event made a deep impression upon his mind. Napoleon, according to St Cyr, manifested no displeasure at the reverse, but ascribed it wholly to the peculiar difficulties of the military art. Ney returned,

Ney.

Ney. however, to Paris in a sort of disgrace. Nevertheless, he was again employed in the unfortunate winter campaign of 1814; and he was at Fontainebleau when Napoleon was compelled to abdicate. Ney contributed materially to bring about this event; and he was one of the first generals who submitted to the Bourbons. Having presented himself before Monsieur on the 12th of April, he said to that prince, "Your Royal Highness will see with what fidelity we can serve our legitimate king." He also went to pay his respects to the king at Compiègne, and was there most favourably received. Louis XVIII. himself received his oath as a chevalier of the order of Saint-Louis, confirmed to him all his titles and pensions, and created him a peer of France. Marshal Ney was living at his estate of the Coudreaux when Napoleon, having escaped from the island of Elba, landed on the coast of France in February 1815; and he there received orders from the minister of war to repair to his government of Besançon. He immediately proceeded to Paris, and presenting himself before the king, made great protestations of devotion, and, kissing the hand of Louis, declared to him that he would bring back the disturber of Europe in an iron cage. He then set out for the eastern frontier, assembled some regiments at Besançon, and placing himself at their head, proceeded towards Lyons. At Lons-le-Saulnier, however, he learned that Napoleon had already entered Lyons; and from this time great agitation manifested itself amongst the troops. Nevertheless, the marshal himself still appeared faithful to the king, and even exerted himself to calm the excitement which prevailed in the army; but in the night between the 13th and 14th of March, an emissary sent by General Bertrand brought him proclamations and letters from Napoleon. His old master knew well that the heroic marshal was much more at home in the field of battle than amid the mazes of political intrigue. Bonaparte accordingly made him brilliant promises, and styled him, as formerly, "the bravest of the brave." The marshal could not resist the seductions of the great general, and next day he read to the troops his famous proclamation, beginning with these words, "The cause of the Bourbons is for ever lost. It is the Emperor Napoleon, our sovereign, who is alone entitled to reign." His whole conduct during the Hundred Days was a consequence of this step. Napoleon sent him as extraordinary commissioner to survey the frontiers of the North, and also appointed him a member of his Chamber of Peers. In the short but decisive campaign which ensued he displayed all his accustomed gallantry. At Quatre-Bras, however, his usual success did not attend him. Five horses were shot under him at Waterloo; yet with a dauntless spirit, which no danger could quell, he headed the terrible charge of the guards on foot, his clothes pierced thick with balls. And when that fierce conflict was over, and his wild daring proved bootless, he was among the last to leave the bloody field. After the defeat of the French army he returned to the capital. When Paris capitulated, Ney, having no hopes of finding favour with the Bourbons, took refuge in Auvergne, where he was arrested in consequence of the ordinance of the 24th of July, in which he was described as one of the authors of the revolution of the 20th March. Being conducted to Paris, he was confined in the Conciergerie, subjected to several interrogatories, and at length brought before a court-martial, composed of marshals of France and lieutenant-generals, to whose competency he objected. His counsel insisted much upon this point, in which they were ultimately successful; the members of the court being glad to escape from an embarrassing position, by pronouncing their own incompetence to try the prisoner. By an ordinance of the king, Ney was then brought before the court of the peers, whose competency was not disputed. But his counsel remonstrated warmly against the expressions employed by the ministers, who had declared that it was "in the name of Europe" that they demanded his trial; and the same learned persons appealed with much force and eloquence to the conditions of the capitulation of Paris, which guaranteed to all who were within the walls of the capital that they should neither be disturbed nor sought after on account of their political conduct. All their efforts to save their client were, however, unavailing. After fifteen sittings, Marshal Ney was condemned to death, on the 6th of December 1815, by a large majority; and the following day the sentence was carried into execution. "He who," says Napier (*Peninsular War*, vol. ii.), "had fought 500 battles for France—not one against her—was shot as a traitor" by a platoon of veterans, near the palace of the Luxembourg, where he had been condemned; and displayed in his last moments the same heroic courage which had so often distinguished him in the field of battle. His body was given to his friends, and conveyed to the cemetery of Père la Chaise, where his tomb may now be seen. Marshal Ney and Colonel Labédoyère were the only victims of a revolution where it is evident that neither played the principal part, and that both were led away by the force of circumstances, and the spell which Napoleon exercised over the minds of the officers as well as the common soldiers of the army. (J. B—E.)

Neyva ‖ Ngami.

NEYVA, or NEIVA, a town of New Granada, on the Magdalena, at its confluence with the River Neyva, 130 miles S.W. of Bogota. It is a place of considerable trade, chiefly in cacao of excellent quality. It suffered much from an earthquake in 1827, but is still a place of some importance.

NGAMI, a lake of Southern Africa, lying between S. Lat. 20. 23. and 20. 40.; E. Long. 22. 30. and 24. Reports of the existence of this lake had been received a long time before it was actually reached by European travellers; it occurs on Portuguese maps as early as 1508; and its position was laid down with considerable accuracy nearly twenty years before it was visited by Livingston, Murray, and Oswell, July 28, 1849. They approached it from the south, having crossed the Kalahari Desert, which had for a long time presented an insuperable obstacle to any attempts to explore the country in this direction. Four years afterwards the lake was again reached by Mr Anderson, who, following a course which had been formerly deemed impracticable, started from Walfisch Bay, on the W. coast of Africa, arrived at the western end of the Ngami, and then travelled round a great part of its banks. The discovery is of very great interest and importance, not only because it enlarges our knowledge of the geography and natural history of the interior of Africa, but also as it may tend to open up those hitherto inaccessible regions to the influences of commerce, civilization, and religion. The lake is known by the natives under various names, derived from its different characteristics, such as *Inghate*, or the "Giraffe;" *Noka ea Mokoròn*, or the "Lake of Boats," &c.; but that which has been adopted by Europeans is *Ngami*, which signifies "The Waters." Its size was at first somewhat over-estimated, on account of the low and almost undistinguishable character of part of its banks, and in consequence of the original discoverers having mistaken its length for its breadth. It extends from E. to W., having a length of about 40 miles, a breadth at the widest part of 10, and an average breadth of 8 miles. Its circumference is about 70 or 80 miles, and its area about 295 square miles. Its shape is somewhat like that of a pair of spectacles, being narrow in the middle and spreading out at each end to a considerable width. Its northern bank is lined by a low and sandy tract of country, entirely destitute of vegetation. This region has a breadth of about a mile, beyond which distance the country is thickly wooded with various kinds of acacia and other trees, among which the enormous baobab is here and there seen raising its head

Ngami.

above the forest. The southern and western shores are considerably higher; and the water is bordered by strips of ground so thickly covered with reeds and rushes as to admit of access to the lake only at a few points. The water is very shallow at the western end of the lake; but the depth is more considerable towards the eastern extremity. A remarkable peculiarity of the waters of the Ngami is, that they are subject to a regular ebb and flow every twenty-four hours. The ebb takes place during the night, when the wind that prevails during the day entirely falls, but in the morning the waters return to their original position. This curious phenomenon has been supposed to depend on the wind. Lake Ngami is fed by the Teoge, which enters it from the N.W., and discharges into it a considerable volume of water during the time of its annual rise, which occurs in June, July, and August, and sometimes later. This river has not as yet been explored to any great distance; but it is believed to be of great length, rising probably near the sources of the Coanza and other large rivers. Its course is very circuitous, and it is said to be wider further up than it is near the lake. During the time of flood its depth is considerable; and it has been navigated with canoes for about 65 miles from the lake. An outlet to the waters of the lake is furnished at its eastern extremity by the broad and gently-flowing river Zouga, which pursues an easterly course for about 300 miles, and is then lost in an immense sandy marsh, though it has been supposed by some that it pursues its course underground, and finally discharges itself into the Indian Ocean. A branch of the Teoge is said to join this river, and at some seasons of the year to force back its waters to the lake. The scenery along the Zouga is extremely beautiful, and the thick and luxuriant forests in many places extend to the very edge of the water. To the west of the Teoge two other rivers are reported to exist, one of which is small, and loses itself in the sand; while the other flows parallel to the Teoge, but in an opposite direction, and joins the Cunenè, a river which falls into the Atlantic. By this latter river it is probable navigation might be established from the sea-coast to the fertile land in the interior. A great number of wild animals are found in the neighbourhood of the lake, of which the elephant, rhinoceros, buffalo, giraffe, and antelope, are the principal. Hippopotami are numerous, especially at the north-western extremity of the lake; and the rivers and lake abound in otters and crocodiles. The birds of this region are also many and various, including many species of ducks and geese, herons, storks, cranes, &c. The inhabitants of the lake country are called *Batoana*, and form a small tribe of the large and powerful family of the Bechuanas, who are widely spread throughout Southern Africa. This tribe, however, is not aboriginal in this district, but has only recently settled here, having conquered and reduced to slavery the original inhabitants, who called themselves *Bayeye*, or "men;" but are styled by the Batoana, *Bakoba*, or "serfs," in consequence of their condition. The appearance of the Batoana is handsome; but the women are generally short and stout, and they encumber themselves with numerous strings of beads, and with iron, brass, and copper rings on their arms and legs. They smear their bodies with grease and red ochre, which they conceive to be a much superior practice to washing themselves. They are extremely fond of snuff, and indulge much, especially the women, in the habit of smoking. The principal occupations of the men are, war, hunting, and the making of skins and furs into garments; while to the women are left the more arduous tasks of building the house, cultivating the ground, preparing the corn, and rearing the family. They are not deficient in intelligence, but this for the most part takes the form of deceitfulness and cunning; and though outwardly they are frank and well-behaved, this arises rather from their habits of politeness and etiquette than from real kindliness of disposition. They are much given to revenge, but easily appeased by presents. The prevailing vice among this people is theft, and even their chiefs are not safe from their pilfering propensities. They have no religion, nor any notions of a Supreme Being; but they believe implicitly in wizards, and especially in the "rain-makers," although they frequently put them to death when disappointed in their expectations. The government is monarchical and patriarchal, each tribe being governed by a chief, who resides in the principal town, and has under him several inferior chiefs at the head of the smaller towns and villages. These inferior chieftains maintain a check on the power of the king, which is in other respects despotic. They assemble in meeting called *pichos*, where speeches are often heard of considerable ability and even eloquence. The principal town of the Batoana tribe is situated at the east end of the lake, on the north bank of the Zouga. The principal articles of commerce that have yet been found in the lake district are hides and furs of different sorts, ostrich feathers, rhinoceros' horns, and ivory; while the natives demand in exchange beads and ammunition, but especially the latter. (See *Lake Ngami; or, Explorations and Discoveries during Four Years' Wandering in the Wilds of South-Western Africa*, by Charles John Anderson, London, 1856; and Livingston's *Travels and Memoirs*.)

Nganhoei || Nicæa.

NGANHOEI, an inland province of China, bounded on the N.E. by Kiangsoo, S.E. by Chekiang, S. by Kiangsee, W. and N.W. by Houpe and Honan. It lies between N. Lat. 29. 5. and 34. 18., and E. Long. 114. 50. and 119. 17.; and has an area of 48,461 square miles. The surface for the most part is level; but towards the south and west ranges of hills occur, never, however, rising to any great height. The principal rivers are the Yang-tse-Kiang and the Hoai-ho, with their affluents. There are several lakes, of which the Chau-hu, or Nest Lake, is the largest. Mines of gold, silver, copper, &c., are worked; and the soil is very productive, especially of green tea, in the south-eastern regions, which are the best in China for the growth of this plant. Ink and lanterns are the principal manufactures of the province. Pop. 34,168,059.

NIAGARA. See CANADA.

NICÆA (*Ishnik* or *Isnik*), a well-built and important city of Bithynia, stood in a spacious and fertile plain on the eastern shore of the Lake of Ascania (*Lake of Isnik*). According to one tradition, it was built by some of Alexander's soldiers, natives of Nicæa in Locris, and derived its name from the birth-place of its founders. Another account, however, states that it was erected on the ruins of a former town (Ancore or Helicore), by Antigonus, and was called after him *Antigoneia*, and that this name was afterwards changed into Nicæa, in honour of Nicæa, the wife of Lysimachus. The town enjoyed a long career of prosperity under the different governments that successively ruled over it. Under the native kings of Bithynia it was important enough to compete with Nicomedia for the honour of being considered capital of the country. During its subjection to the Romans many of its public buildings were restored, and its streets were often the scene of the celebration of great festivals in honour of the emperors and the gods. In the time of the Eastern Empire the city was enlarged, was surrounded with new walls, and became famous throughout Christendom as the place where, in 325 A.D., the Nicene creed was drawn up. (See NICE, *Council of*.) After being during the middle ages a frequent subject of dispute between the Turks and the Christians, it was constituted by Theodore Lascaris, in the thirteenth century, the capital of Western Asia. At length, however, in the fourteenth century, on being incorporated with the Ottoman empire by the Emir Orchan, Nicæa began to decline in prosperity.

Nicæa ‖ Nicaragua.

Many of the fine Greek temples and churches were then pulled down to furnish materials for mosques and other buildings. From that time the large city gradually dwindled down until, in the present day, it has become a poor paltry village of little more than a hundred houses. Yet many ruined baths and edifices standing amid gardens and cornfields, and a large portion of the ancient walls, still indicate to the visitor the splendour and magnitude of the ancient Nicæa.

NICÆA, a town of Liguria. See NICE.

NICANDER, the author of two Greek poems on poisons and antidotes, was a native of Claros near Colophon in Ionia, and flourished in the second century B.C., in the reign of Attalus, the last king of Pergamus. He succeeded his father Damnæus in the hereditary office of priest of Apollo Clarius. His poems show that he possessed a fine talent for observation, and was fully equal to the other naturalists of his own age. The other features, however, of his literary character are not so favourable. His dissertations were unmethodical and often prolix; he was ever on the outlook for obsolete and antiquated expressions, which must often have rendered his meaning obscure even to his contemporaries; and almost the only quality of the poet he evinced was a fondness for the strange and the fabulous. The longer of his two extant poems is entitled *Theriaca*, treats of the wounds inflicted by poisonous animals, and consists of nearly a thousand hexameter verses. Among the curious zoological passages which are found heterogeneously mingled with erroneous doctrines and absurd fables, are the first account ever given of the moths that flutter round the evening candle, and an interesting description of the resistance that the serpents make in defence of their eggs against the ichneumon. The other poem, entitled *Alexipharmaca*, is a treatise, as its name implies, on antidotes, and contains more than 600 hexameter lines. It seems to have been intended for a continuation of the *Theriaca*, and accordingly it gives an account of the effect of different poisons. A full analysis of the medical portions of these two poems is given in Dr Adams' edition of the work of Paulus Ægineta. Nicander was the author of several other productions, both prose and poetical, of which little more than the titles remain. The best edition of his works, entire and fragmentary, is that of J. G. Schneider, in two volumes, published respectively at Halle in 1792, and at Leipsic in 1816.

NICARAGUA, an independent republic, formerly one of the states of the Republic of Central America, and, under the Spanish dominion, one of the provinces of the captain-generalcy, called also the kingdom, of Guatemala. The boundaries claimed by the republic of Nicaragua are those which pertained to it as a province, viz.,—the Caribbean Sea on the E., from the lower or Colorado mouth of the San Juan River to Cape Gracias á Dios; and the Pacific Ocean on the W., from the mouth of the Rio Salto de Nicoya or Alvarado on the Bay of Nicoya to the Bay of Fonseca. On the N., and separating it from Honduras, its boundary extends from the mouth of the Rio Negro, falling into the Bay of Fonseca, to the head-waters of the Rio Wanks or Segovia, following down that river to the sea at Cape Gracias. Its southern boundary, separating it from Costa Rica, is claimed to be a right line drawn from the Colorado mouth of the San Juan river to the mouth of the Rio Salto de Nicoya. Nicaragua is, therefore, embraced between 83. 20. and 87. 30. W. Long., and 9. 45. and 15. N. Lat., and, according to these claims, embraces an area of not far from 59,000 square miles.

A considerable part of this territory, however, embracing the entire Atlantic coast, with an undefined extent inland, from the River San Juan to Cape Gracias, has been claimed on behalf of the Mosquito Indians (see MOSQUITO SHORE); but the claim has never been conceded by Nicaragua. The whole territory south of the River San Juan, and below the little River Flores, flowing into the Pacific, embracing the ancient department of Guanacaste, has been claimed by Costa Rica, and is at present in the actual occupation of that state. Should these claims be ultimately admitted, they will reduce by nearly one half the territorial area of the republic. Nicaragua.

The geographical and topographical features of Nicaragua are not only remarkable, but interesting to the world at large, from the facilities which they are supposed to afford for opening a ship-canal between the Atlantic and Pacific Oceans. The northern part of the republic, embracing the whole of the district of Segovia, and a portion of Chontales, borders on the high grounds or plateau of Honduras, and partakes of its mountainous character. The valleys are narrow, and the numerous streams which flow through them rapid and turbulent. The hills are clothed with pines and oaks, and the aspect and climate of the region are those of the temperate zone. Here are found numerous rich mines of gold, silver, and copper; and many of the streams carry gold in their sands, whence it is washed in considerable quantities by the Indians. To the southward of this elevated district, and between it and the high mountain group or centre of elevation in Costa Rica, is the great basin of the Nicaraguan lakes, lying transversely to the great range of the Cordilleras, and completely interrupting it. It is precisely this physical feature which has directed attention to Nicaragua, as probably the best point where the oceans may be connected by a canal. This great basin or valley is not far from 300 miles long by 150 miles wide, and consists in great part of broad, beautiful, and fertile plains. In its centre are spread out the Lakes of Nicaragua and Managua, which collect the waters flowing inward from every direction, and discharge them through a single outlet, the Rio San Juan, into the Caribbean Sea. Some of the streams flowing into these lakes, especially those from the north, are of considerable size, and furnish a supply of water which could not be sensibly affected by drains for artificial purposes. Lake Managua is a beautiful sheet of water, nearly 50 miles long by 25 broad, and with an average depth of 5 fathoms of water. It approaches, at the nearest point, to within 20 miles of the Pacific Ocean, from which it is separated on the south by a range of low volcanic hills; but between its northern extremity and the sea there are only the magnificent plains of Leon and El Conejo, in the midst of which rise the regular cones of the volcanoes of El Viejo, Telica, and Axusco. The gigantic volcano of Momotombo stands out boldly into the lake; its bare and blackened summit, which no human foot has ever pressed, crowned with a light wreath of smoke, attesting the continued existence of those internal fires which have seamed its steep sides with burning floods, and which still send forth hot and sulphurous springs at its base. Upon the northern and eastern shores of the lake, lifting their blue, rugged peaks one above another, are the mountains of Matagalpa, gradually merging into those of Segovia, rich in metallic veins. Upon the south and west are fertile slopes and broad plains, covered with luxuriant verdure, and of almost unlimited productiveness; while in the lake itself stands the Island of Momotombita, an almost perfect cone in outline, covered with a dense forest, in the deepest recesses of which are still found gigantic idols, the rude relics of aboriginal superstition. The town of Leon was first built on the north-western shore of the lake, at a place now called Moabita, which was subsequently abandoned for its present site, in the midst of the great plain of the Marabios. From this circumstance the lake is sometimes called Lake Leon. The great feature of Nicaragua, however, is the lake of the same name, the Cocibolca of the aborigines, which is unquestionably one of the finest bodies of water on the American continent. It is upwards of 100 miles in greatest length, by about

Nicaragua. 40 miles in average width. Upon its southern shore, near the head of the lake, stood the ancient city of Granada, lately the rival of Leon, and once the most important commercial town in the republic. A few miles below Granada, and projecting boldly into the lake, is the extinct volcano of Mombacho, 5000 feet in height. Studding the lake at its base, is a cluster of innumerable small islands called *Los Corales*, of volcanic origin, rising in the form of cones to the height of from 20 to 100 feet, and covered with verdure. Upon the same shore with Granada, but 40 miles distant, is the ancient city of Rivas or Nicaragua, the capital of a large, fertile, and comparatively well cultivated district. Flowing into the lake, at its extreme southern extremity, nearly at the same point where the Rio San Juan (the ancient *El Desaguadero*) commences its course, is the considerable Rio Frio, which has its origin at the base of the great volcano of Cartago in Costa Rica. It flows through an unexplored region, inhabited by an unconquered and savage tribe of Indians called Guatusos, of whose ferocity the most extraordinary stories are related. The northern shore of the lake, called Chontales, for the most part is undulating, abounding in broad savannas, well adapted for grazing, and supporting large herds of cattle. There are a number of considerable islands in the lake, the largest of which are El Tapatero, Solentenami, and Omotepec. The two former are deserted, but the latter has a considerable population of Indians of the pure Mexican or Aztec stock. This island is distinguished by two high conical mountains or volcanic peaks, called respectively Omotepec and Madeira, which are visible from every part of the lake, and from a distance of many leagues on the Pacific. The name of the island, in the Nahuatl or Mexican language, signifies "two mountains," from *ome*, two, and *tepec*, mountain. The water of the lake, in most places, shoals very gradually; and it is only at a few points that vessels of considerable size may approach the shore. Still, its general depth, for all purposes of navigation, is ample, except near its outlet, where for some miles it does not exceed from 5 to 10 feet. There are points, however, where the depth of water is not less than 40 fathoms. The prevailing winds on the lake, as indeed of the whole state, are from the N.E.; they are, in fact, the Atlantic trades, which here sweep entirely across the continent, and encountering the conflicting currents of air on the Pacific, form those baffling revolving winds, detested by navigators, under the name of *Papagayos*. When the winds are strong the waves of the lake become high, and roll in with all the majesty of the ocean. At such times the water of the lake is piled up, as it were, on the southern shore of the lake, occasionally producing overflows of the low grounds. As the trade winds are intermittent, blowing freshly in the evening, and subsiding towards morning, the waters of the lake seem to rise and fall accordingly; and this circumstance gave rise to the notion, entertained and promulgated by the ancient chroniclers, that the lake had a regular tide like that of the sea. Some of them imagined, in consequence, that it communicated with the ocean by a subterranean channel. As already observed, the sole outlet of the great Nicaraguan basin, and of the lakes just described, is the River San Juan, debouching into the Caribbean Sea, at the now well-known port of San Juan (Greytown). This river is a magnificent stream, but its capacities have been greatly exaggerated, as will be seen in the paragraphs referring to the proposed ship-canal. It flows from the south-eastern extremity of Lake Nicaragua, nearly due east to the ocean. With its windings it is 119 miles long. The body of water which passes through it varies greatly at different seasons of the year. It is, of course, greatest during what is called the "rainy season;" that is to say, from May to October. To this variation, in some degree, may be ascribed the wide difference in the statements of the depth and capacity of the river made by different observers. Several considerable streams enter the San Juan, the largest of which are the San Carlos and Serapiqui, both rising in the highlands of Costa Rica. The streams flowing in from the north are comparatively small; indicating that the mountains are not far distant in that direction, and that upon that side the valley is narrow. The Serapiqui is ascended by canoes to a point about 20 miles above its mouth, where commences the road, or rather mule-path, to San José, the capital of Costa Rica. About midway between the lake and the ocean, on the south bank of the river, are the ruins of the old fort or castle of San Juan, captured by the English in 1780. The expedition against it was commanded by Colonel Polson, with captain, afterward Lord Nelson, as second in command. Of 200 men under Nelson, drawn from his vessel, the Hinchenbrook, but ten returned to the coast. At one time, besides this fort, another at the head of the river (San Carlos), and a third at its mouth, the Spaniards kept up not less than twelve military stations on its banks. The width of the river varies from 100 to 400 yards, and its depth from 2 to 20 feet. It is interrupted by five rapids,—viz., Rapides del Toro, del Castillo, de los Valos, del Mico, and Machuca. The Machuca rapids are the largest, and in many respects the worst in the river. For a distance of nearly half a mile the stream is spread over a wide and crooked bed, full of large rocks projecting above the surface, between which the water rushes with the greatest violence. They are considered dangerous by the native boatmen, who are only enabled to ascend them by keeping close to the northern shore, where the current is weakest, and the bed of the river least obstructed. Here the *bougos* or boats are pushed up by main force. The late Transit Company lost a number of their small steamers on these rapids, which, without great artificial improvement, must remain an insuperable obstacle to regular steam navigation on the river. The rapids of El Castillo are short, and deserve rather the name of falls. Here the water pours over an abrupt ledge of rocks, falling 8 feet in but little more than the same number of yards. Bougos are unloaded here, and the empty boats trucked past by men stationed there for the purpose. The steamers of the Transit Company did not attempt to pass these rapids, the passengers and merchandise being transferred by means of a tram-road to vessels above. The remaining rapids, although formidable obstacles to navigation, do not require a special description. The banks of the San Juan, for 20 miles from the lake, and for about the same distance above its mouth, are low and swampy, lined with palms, canes, and a variety of long coarse grass called *gamalote*. Elsewhere the banks are generally firm, in some places rocky, from 6 to 20 feet high, and above the reach of overflows. They are everywhere covered with a thick forest of large trees, draped all over with *lianes* or woodbines, which, with the thousand varieties of tropical plants, form dense walls of verdure on both shores of the stream. The soil of the river-valley seems uniformly fertile, and capable of producing abundantly all tropical staples. Like the Atrato, the San Juan river has formed a delta at its mouth, through which it flows for 18 miles, reaching the sea through several channels. The largest of these is the Colorado Channel, which opens directly into the ocean; the next in size is that which bears the name of the river, and flows into the harbour of San Juan. Between the two is a smaller one called Tauro. This delta is a maze of low grounds, swamps, creeks, and lagoons, the haunts of the manati and alligator, and the homes of innumerable varieties of water-fowl. The port of San Juan (Greytown) derives its principal importance from the fact that it is the only possible eastern terminus for the proposed inter-oceanic canal, by way of the River San Juan and the Nicaraguan lakes. It is small, but well protected,

Nicaragua. easy of entrance and exit, and has a depth of water varying from 3 to 5 fathoms. Upon the Pacific the best port of the republic is that of Realejo, anciently Posession, which is capacious and secure, but difficult of entrance. The little bay of San Juan del Sur, which was used as the Pacific port of the late Transit Company, is small and insecure, and scarcely deserves the name of harbour. The same may be said of the so-called ports of Brito and Tamaranda. A good port is said to exist on Salinas Bay; but this falls on that part of the coast in dispute with Costa Rica.

Next to its great lakes, the most striking physical features of Nicaragua are its volcanoes, which bristle along its Pacific coast, in nearly a right line, from the Bay of Fonseca to that of Nicoya. Commencing at the volcano of Cosequina, we come in order to El Viejo, Santa Clara, Telica, Las Pilas, Orota, Axusco, Momotombo, Masaya or Nindiri, Mombacho, Ometepec, Madeira, Solentanami, and Orosi, of which Cosequina, Momotombo, Masaya, and Orosi are said to be *vivo*, or active. Besides these volcanic peaks, there are numerous ancient craters and fissures giving forth smoke and sulphurous vapours, called *Infernillos*. At the time of the conquest of Nicaragua, in 1520, the volcano of Masaya, then called the "Hell of Masaya," was in active eruption. Oriedo, the chronicler of the Indias, has left us a graphic account of it as it then appeared. It has had one or two violent eruptions since that period, and after more than half a century of quiescence, is now (1857) throwing out volumes of smoke, and giving other evidences of renewed activity. It is a low, broken mountain, and the country for miles around its base is covered with lava. The volcanoes on the plain of Leon, known as Los Marabios, were also active at the period of the conquest; and as late as Dampier's time, El Viejo was "a volcano or burning mountain." Momotombo to this day sends out a constant column of smoke, and an occasional cloud of ashes. The eruption of the volcano of Cosequina in 1835 was one of the most fearful on record. It commenced on the 30th of January of that year, and continued with uninterrupted violence for four days, and then suddenly ceased. For three days the clouds of smoke and sand which it sent forth totally obscured the sun for the distance of a 100 miles. Sand fell in Jamaica, in Santa Fe de Bogota, and in Mexico, over an area of more than 1500 miles in diameter. The explosions were heard 800 miles; and a ship off the coast sailed for 50 leagues through floating masses of pumice, which almost entirely concealed the surface of the water. Since 1835 this volcano has remained perfectly quiet, with no signs of activity, except a few rills of smoke and vapour, indistinguishable at a distance. The volcano of Orosi is in a state of constant activity. Besides the volcanoes themselves, and the hundred yawning craters amongst the hills, there are numerous lakes of volcanic origin, shut in by vitrified, blistered, and precipitous walls of rock, without outlets, and often of great depth. Such is the remarkable Lake of Masaya, near the volcano of the same name, which furnishes water, not only to the considerable town of Masaya, but also to the inhabitants of numerous villages in its vicinity. It is about 10 miles in circumference, and its surface 500 feet below the general level of the country. The water is reached by steep, narrow paths, half cut in the rock, and is carried up by the *aquadoras* in jars, supported on their heads, or on their backs, by bands passing around their foreheads. In some of these volcanic lakes the water is fresh and good; in others salt and bitter. Perhaps no equal extent of the earth's surface exhibits so many or so marked traces of volcanic action as that part of Nicaragua intervening between its lakes and the Pacific Ocean.

The climate of Nicaragua, except among the mountains of Chontales and Segovia, is essentially tropical, but nevertheless considerably modified by a variety of circumstances. The absence of high mountains towards the Atlantic, and Nicaragua. the broad expanse of its lakes, permits the trade-winds here to sweep entirely across the continent, and to give to the country a degree of ventilation agreeable to the senses, and favourable to health. The region towards the Atlantic is unquestionably warmer, more humid, and less salubrious, than that of the interior, and of the country bordering on the Pacific. The Nicaragua basin proper, and within which the bulk of its population is concentrated, has two distinctly marked seasons, the wet and the dry; the first of which is called summer, the latter winter. The wet season commences in May, and lasts until November; during which time, but usually near the commencement and the close, rains of some days' duration are of occasional occurrence, and showers are common. The latter do not often happen except late in the afternoon, or during the night. They are seldom of long continuance, and often days and weeks elapse, during what is called the rainy season, without a cloud obscuring the sky. Throughout this season, the verdure and the crops, which, during the dry season, become sere and withered, appear in full luxuriance; the temperature is very equable, differing a little according to locality, but pursuing a very nearly uniform range from 78° to 88° of Fahrenheit; occasionally sinking to 70° in the night, and rising to 90° in the afternoon. During the dry season, from November to May, the temperature is less, the nights positively cool, and the winds occasionally chilling. The sky is cloudless; and trifling showers fall at rare intervals. The fields become parched and dry, and the cattle are driven to the borders of the streams for pasturage; while in the towns the dust becomes almost insufferable. It penetrates everywhere, sifting through the crevices of the tiled roofs in showers, and sweeping in clouds through the unglazed windows. This season is esteemed the healthiest of the year. Its effect is practically that of a northern winter, checking or destroying that rank and ephemeral vegetation which, constantly renewed where the rains are constant, as at Panama, form dense, dark jungles, the birth-places and homes of malaria and death. For the year commencing September 1850, and ending September 1851, the thermometer at the town of Rivas gave the following results:—Mean highest, 86°·45 of Fahr.; mean lowest, 71°·15: mean average for the year, 77°·42; mean range, 15°·3. The amount of rain which fell from May to November inclusive was 90·3 inches; from December to April inclusive, 7·41 inches. None fell in February; but 22·64 inches fell in July, and 17·86 inches in October.

The natural resources of Nicaragua are very great. The staples of the tropics, cotton, sugar, indigo, tobacco, rice, cacao, coffee, &c., may be produced in the greatest abundance. The cotton, although as yet, from lack of sufficient labour, produced in but small quantities, is of a superior quality. The cacao of Nicaragua has long been celebrated as next only to that of Soconusco in quality and value. Its sugar is produced from a plant slenderer, but containing more and stronger juice, than the variety cultivated in the West India Islands. Two crops, and sometimes, when the fields are irrigated, three crops are taken from the same ground annually. This cane seldom requires to be replanted oftener than once in twelve or fourteen years. The crystals of the sugar are remarkably large and fine; and the sugar itself, when carefully manufactured, nearly equal in beauty to the refined sugar of commerce. The indigo is produced from an indigenous plant called *juiquilite* (*Indigofera disperma*, Lin.), and has a high reputation in commerce. Coffee flourishes well on the higher grounds, but is not extensively cultivated. The same may be said of tobacco, which is a government monopoly, and its production not allowed, except in certain quantities. Maize grows in great perfection, and, manu-

Nicaragua. factured into *tortillos*, constitutes a principal article of food. Cattle are numerous, and hides form a large item amongst the exports of the country. Dye-woods, chiefly the *braziletto*, are also extensively exported. In short, nearly all the edibles and fruits of the tropics are produced naturally, or may be cultivated in great perfection; plantains, bananas, beans, tomatoes, yams, arrow-root, citrons, melons of all kinds, limes, lemons, oranges, pine-apples, guavas, cocoa-nuts, and many other varieties of fruits and vegetables. Among the vegetable productions which enter into commerce, may be mentioned sarsaparilla, arnotta, vanilla, ginger, gum-copal, gum-arabic, copaiba, caoutchouc, dragon's-blood, &c. The mineral resources of Nicaragua are also very great. Gold, silver, copper, lead, and iron are found in considerable quantities in various parts, but chiefly in the districts of Segovia and Chontales. The production of these metals has greatly fallen off since the assertion of the country's independence; still the produce is considerable; but such is the unsettled state of the country, it is impossible to obtain any satisfactory statistics concerning it. Sulphur may be had in inexhaustible quantities, crude and nearly pure, from the volcanoes; nitre is also abundant, as also sulphate of iron. Notwithstanding the variety of its products, and the ease with which they may be prepared for market, the commerce of Nicaragua is very small. The wants of its people are few and easily supplied.

Politically, Nicaragua is divided into five departments, exclusive of the disputed department of Guanacaste, each of which is subdivided into districts for municipal and other purposes. The departments are as follows:—

Departments.	Capitals.	Population.
Meridional	Rivas	20,000
Oriental	Granada	95,000
Occidental	Leon	90,000
Septentrional of Matagalpa	Matagalpa	40,000
Septentrional of Segovia	Segovia	12,000
	Total	257,000

The population here given is the result of a census attempted in 1846. Making due allowance for deficiencies, we may estimate the actual population of Nicaragua at not less than 300,000; and it may be divided as follows, with approximate exactness:—

Whites	30,000
Negroes	18,000
Indians	96,000
Meztizos	156,000
Total	300,000

The people generally live in towns, many of them going 2, 4, and even 6 miles, to labour in their fields, starting before dawn, and returning in the evening. The plantations, *haciendas*, *hattos*, *huertas*, &c., are scattered over the country, and are often reached by paths so obscure as almost wholly to escape the notice of the travellers. The dwellings are usually of canes, thatched with palm, many of them open at the sides, with no other floor than the bare earth, and deserving of no better name than that of huts. These fragile structures, so equable and mild is the climate, are adequate to such protection as the natives are accustomed to consider necessary. Some of the dwellings are more pretending, are roofed with tiles, and have the canes plastered over and white-washed; and there are a few, belonging to large proprietors, which are roomy, neat, and comfortable. In the towns, the residences of the better classes are built of *adobes* or sun-dried bricks, inclosing large courts, faced by broad corridors. The churches, as usual in Catholic countries, monopolize nearly all that there is of architectural skill and beauty. Their leading features are Moresque; but there are a few, and conspicuously among them the great cathedral of Leon, which are of simpler and more classical styles. This cathedral is of substantial masonry throughout. It was finished in 1743, after having occupied thirty-seven years in building. The cost is said to have been L.1,000,000 sterling. Nothing can better illustrate its strength than the fact, that it has endured unimpaired the earthquakes and storms of more than a century. During the frequent revolutionary paroxysms of the country, it is used as a fortress, heavy guns being mounted on the roof. It has sustained several severe cannonades. Nicaragua.

The project of opening a canal for ships through Nicaragua began to be entertained as soon as it was found that no natural communication existed between the oceans, as early as 1527. Since that period it has furnished a subject for much speculation; but beyond a few partial examinations, until very lately, nothing of a practical or satisfactory character had been attempted. In 1851 a careful survey was made of the River San Juan, Lake Nicaragua, and the isthmus intervening between this lake and the Pacific, by Colonel Childs, under the direction of the now extinct "Atlantic and Pacific Ship Canal Company." Until then, it had always been assumed that the River San Juan, as well as the lake itself, could easily be made navigable for ships, and that the only obstacle to be overcome was the narrow strip of land between the lake and the ocean. Hence, all the so-called surveys were confined to that point alone. One of these was made, under the orders of the Spanish government, by Don Manuel Galisteo, in 1781. Another, and that best known, by Mr John Baily, under the direction of the government of Central America in 1838. An intermediate examination, quoted by Thompson, seems to have been made early in the present century. The following table will show the results of these surveys as regards this particular section:—

Authorities.	Distance from Lake to Ocean.	Greatest Elevation above Ocean.	Greatest Elevation above Lake.
	Miles feet.	Feet.	Feet.
Galisteo, 1781	17 200	272	134
Quoted by Thompson, 18—	17 330	296	154
Baily, 1838	16 730	615	487
Childs, 1851	18 588	159	47½

As the survey of Colonel Childs is the only one which can be accepted as conforming to modern engineering requirements, it will be enough to present the detailed results at which he arrived. The line proposed by him, and on which all his calculations and estimates were based, commences at the little port of Brito on the Pacific, and passes across the isthmus between the ocean and the lake, to the mouth of a small stream called Rio Lajas, flowing into the latter; thence across Lake Nicaragua to its outlet, and down the valley of the Rio San Juan to the port of the same name, on the Atlantic. The length of this line was found to be 194¾ miles as follows:—

	Miles.
Western Division:—Canal from the port of Brito on the Pacific, through the valleys of the Rio Grande and Rio Lajas, flowing into Lake Nicaragua	18·588
Middle Division:—Through Lake Nicaragua, from the mouth of Rio Lajas to San Carlos at the head of the San Juan River	56·500
Eastern Division—First Section:—Slack water navigation on San Juan River, from San Carlos to a point on the river nearly opposite the mouth of the Rio Serapiqui	90·800
Second Section:—Canal from point last named to port of San Juan del Norte	28·505
Total as above	194·393

The dimensions of the canal were designed to be—Depth 17 feet; excavations in earth, 50 feet wide at bottom, 86 feet wide at 9 feet above bottom, and 118 feet wide at surface of water; excavations in rock 50 feet wide at bottom, 77 feet wide at 9 feet above bottom, and 78½ feet wide at surface of water.

The construction of the canal on this plan contemplates supplying the western division, from the lake to the sea, with water from the lake. It would, therefore, be necessary to commence the work on the lake at a point where the water is 17 feet deep at mean level. This point is opposite the mouth of the little Rio Lajas, and twenty-five chains from the shore. From this point, for 1½ mile, partly along the Rio Lajas, the excavation will be principally in earth; but beyond this, for a distance of 5½ miles, which carries

Nicaragua. the line beyond the summit, three-fourths of the excavations would be in trap rock, that is to say, the deepest excavation or open cut would be 64½ feet (summit 47½ feet + depth of canal 17 feet = 64½ feet), and involve the removal of 1,870,000 cubic yards of earth, and 3,378,000 cubic yards of rock. The excavation and construction on this 5½ miles alone was estimated to cost upwards of L.1,250,000. After passing the summit, and reaching the valley of a little stream called Rio Grande, the excavation, as a general rule, would be only the depth of the canal. Mr Childs found that the lake at ordinary high-water is 102 feet 10 inches above the Pacific at high, and 111 feet 5 inches at low tide, instead of 128 feet, as calculated by Mr Baily. He proposed to accomplish the descent to Brito by means of fourteen locks, each of 8 feet lift. The harbour of Brito, as it is called, on the point where the Rio Grande enters the sea, is in fact only a small angular indentation of the land, partially protected by a low ledge of rocks, entirely inadequate for the terminus of a great work like the proposed canal, and incapable of answering the commonest requirements of a port. To remedy this deficiency, it was proposed to construct an artificial harbour of 34 acres area, by means of moles and jetties in the sea and extensive excavations in the land. If, as supposed, the excavations here would be in sand, it would be obviously almost impossible to secure proper foundations for the immense sea-walls and piers which the work would require. If in rock, as seems most likely, the cost and labour would almost surpass computation. Assuming the excavations to be in earth and sand, Colonel Childs estimated the cost of these improvements at upwards of L.540,000.

Returning now to the lake, and proceeding from 17 feet depth of water, opposite the mouth of the Rio Lajas, in the direction of the outlet of the lake at San Carlos, there is ample depth of water for vessels of all sizes for a distance of about 51 miles, to a point half a mile south of the Boceas Islands, where the water shoals rapidly to 14 feet; for the remaining 5½ miles to San Carlos, the depth averaging only 9 feet at low, and 14 feet at high water. For this distance, therefore, an average under-water excavation of 8 feet in depth would be required to carry out the plan of a canal of 17 feet deep. But if the lake were kept at high level, the under-water excavation would have an average of only about 3 feet. Colonel Childs proposed to protect this portion of the canal by rows of piles driven on each side, and supposed that when the excavation should be completed, there would be sufficient current between them to keep the channel clear.

We come now to the division between Lake Nicaragua and the Atlantic through or along the Rio San Juan. Colonel Childs carried a line of levels from the lake at San Carlos to the port of San Juan, and found the distance between those points to be 119½ miles, and the total fall from the level of high-water in the lake to that of high-tide in the harbour, 107½ feet. From San Carlos to a point half a mile below the Serapiqui River, a distance of 91 miles, Colonel Childs proposed to make the river navigable by excavating its bed, and by constructing dams, to be passed by means of locks and short canals; the remaining 28 miles to be constructed through the alluvial delta of the San Juan, inland, and independently of the river. Of the whole fall, 62½ feet occur on that portion of the river which it was proposed to improve by dams, and on which there were to be eight locks; and the remaining 45 feet on the inland portion of the work, by means of six locks,—fourteen locks in all, each with an average lift of nearly 8 feet. It was proposed to place the first dam, descending the river, at the Castillo rapids, 37 miles from the lake, and to pass the rapids by means of a short lateral canal. By means of this dam the river was to be raised at that point 21½ feet, and the level of Lake Nicaragua 5 feet above its lowest stage; or, in other words, kept at high-water mark, to avoid the extensive submarine excavations which would be necessary to enable vessels to enter the river. The fall at this dam would be 16 feet. The other dams were to be four of 8 feet fall, one of 13½ feet, and another of 14½ feet. Between all of these it was found there would be required more or less excavation in the bed of the stream, often in rock. Colonel Childs also proposed to improve the harbour of San Juan by means of moles, &c., and also to construct an artificial harbour or basin, in connection with it, of 13 acres area. As regards the amount of water passing through the San Juan, it was found that at its lowest level, June 4, 1851, the discharge from the lake was 11·930 cubic feet per second. The greatest rise in the lake is 5 feet. When it stood 3·43 feet above its lowest level, the flow of water in the river, at San Carlos, was 18·059 cubic feet per second, being an increase of upwards of 50 per cent. Supposing the same ratio of increase, the discharge from the lake at extreme high-water would be upwards of 23·000 cubic feet per second. The river receives large accessions from its tributaries, which, at the point of divergence of the Colorado channel, swell the flow of water to 54·380 cubic feet per second; of which 42·056 cubic feet pass through the Colerado channel, and 12·324 cubic feet into the harbour of San Juan.

The cost of the work was estimated by Colonel Childs as follows: Nicaragua.

Eastern division (from Port of San Juan to lake),	L.2,604,655
Central division (through lake),	213,682
Western Division (from lake to Pacific),	2,895,126
	L.5,713,463
Add for contingencies 15 per cent.	857,019
Total estimated cost	L.6,570,482

The charter of the company, under the auspices of which Colonel Childs was sent to Nicaragua, stipulated that the canal should be of dimensions sufficient "to admit vessels of all sizes." A canal therefore, such as the proposed, but 17 feet deep, and 118 feet wide at the surface of the water, could not meet the requirements of the charter, nor be adequate to the wants of commerce. To pass freely large merchantmen and vessels of war, a canal would require to be at least 30 feet deep, with locks and other works in proportion, which would involve at least three times the amount of excavation, &c., of the work proposed above, and a corresponding augmentation of cost. A canal so small as to render necessary the transhipment of merchandise and passengers is manifestly inferior to a railway, both as involving, in the first instance, greater cost of construction, and, in the second place, greater expense in working, with less speed.

The surveys and estimates of Colonel Childs were submitted to the British government, and by it referred for report to Mr James Walker, civil engineer, and Captain Edward Aldrich, Royal Engineers. The report of this commission, proceeding on the assumption that the plans, measurements, &c., of Colonel Childs were correct, was on the whole favourable. It, however, suggested that the item of "contingencies" in the estimate should be increased from 10 to 25 per cent. Of all the works of the proposed navigation, it pronounces the Brito or Pacific harbour as least satisfactory. "Presuming the statements and conclusions of Colonel Childs to be correct, the Brito harbour is, in shape and size, unworthy of this great ship navigation, even supposing the Pacific, to which it is quite open, to be a much quieter ocean than any we have seen or have information of." Subsequently the plans and reports were laid before a committee of English capitalists, with a view to procure the means for the actual construction of the work. This committee, after a patient investigation, declined to embark in the work, or to recommend it to public support, on the ground—1*st*. That the dimensions of the proposed work were not such as, in their opinion, would meet the requirements of commerce; 2*d*. That these dimensions were not conformable to the provisions of the company's charter; 3*d*. That supposing the work not to exceed the estimated cost of L.6,500,000, the returns, to meet the simple interest on the investment, at 6 per cent., would require to be at least L.390,000 over and above its current expenses; or to meet this interest, and the percentage to be paid to Nicaragua, not less than L.473,000 over and above expenses; or, allowing L.200,000 per annum for repairs, superintendence, cost of transportation, &c., then the gross earnings would require to be L.680,000 4*th*. Putting the toll at 12s. 6d. per ton, the collection of this revenue would involve the passage of upwards of 1,000,000 of shipping per annum; 5*th*. That not more than one-third of the vessels engaged in the oriental trade could pass through a canal of the proposed dimensions, even if the route which it would open were shorter than that by way of Cape of Good Hope, instead of being more than 1000 miles longer to Calcutta, Singapore, and other leading ports of British India; 6*th*. That the heavy toll of 12s. 6d. per ton on ships would generally prevent such vessels as could do so from passing the canal, inasmuch as on a vessel of 1000 tons the aggregate toll would be L.625, or more than the average earnings of such vessels per voyage; 7*th*. That a work of the dimensions proposed, under the present condition of commerce, would not attract sufficient support to defray the cost of repairs and working, and could not therefore be safely undertaken by capitalists. Upon the publication of this report, the canal company obtained the privilege of opening a transit by steamers and carriages through Nicaragua, the project of a canal was definitively abandoned, and the charter allowed to be forfeited for *non-user*. It was obtained in 1849, for a period of eighty-five years from the completion of the work, for which twelve years were allowed; the canal was to revert to the state at the expiration of the charter; the state to receive for the first twenty years after the opening of the work 20 per cent. annually of its net profits, and thereafter 25 per cent. Other onerous restrictions were imposed, of a nature to deter so large an investment of capital as the work would require; although in these respects the charter was much more liberal than any of those which had previously been conceded for the same purpose. By the terms of the Bulwer-Clayton convention of 1850, Great Britain and the United States have defined

Nicaragua ‖ Niccolo Pisano.

the principles which they agree should apply to an inter-oceanic canal, wherever and whenever constructed:—

1. That neither Great Britain nor the United States will ever obtain or maintain for itself any exclusive control over such work, nor erect fortifications commanding it, or in its vicinity, or make use of its influence or relations with the countries through which such canal may pass, to secure exclusive privileges for itself or its subjects in the same.

2. Neither party to capture or detain the vessels of the other while passing through the canal, or within — leagues of its extremities.

3. To protect the capitalists undertaking the construction of the canal from "unjust interference, seizure, and violence."

4. To use their influence to facilitate the work, and their good offices to procure the establishment of a free port at each extremity of the same.

5. To guarantee the neutrality of the canal so long as its proprietors shall not make unfair discriminations on vessels in transit, or impose unreasonable tolls.

6. To extend the same general protection to every practicable communication, whether canal or railway, across the isthmus of Central America.

The first opportunity for a compliance with the provisions of this convention was afforded in 1856, in which year Great Britain entered into a treaty with Honduras, for the protection and guarantee of the Honduras Inter-oceanic Railway, in strict conformity with the principles here laid down.

The construction of a ship-canal between the oceans through Nicaragua is unquestionably within the range of engineering feasibilities; but it can be as safely affirmed that, with the present requirements of commerce, and under the laws which govern the use of capital, it is not likely to be seriously undertaken. The assumption upon which most of the speculations regarding the utility of such a work are founded, viz., that it would shorten the distance between the ports of Europe and those of Asia in general, is erroneous, as will appear from the following table:—

	Via Cape of Good Hope.	*Via* proposed Canal.	Net Loss.	Net Gain.
From England	Miles.	Miles.	Miles.	Miles.
To Canton	12,900	13,800	900	...
Calcutta	11,440	15,480	4040	...
Singapore	11,880	15,120	4240	...
Sidney, *via* Torres Straits	14,980	12,550	...	2320
From New York				
To Canton	14,100	11,820	...	3280
Calcutta	12,360	13,680	1320	...
Singapore	12,700	1,420	...	1280
Sidney	15,720	9,480	...	5240

It will be observed that the sole advantage which the canal would afford to Great Britain, as regards the East, would be a saving in distance (equally attainable by a railway across the isthmus) of 2320 miles in communicating with Australia. As regards the Sandwich Islands and the western coast of America, the gain in distance, both to England and the United States, would be considerable, as shown in the subjoined table:—

	Via Cape Horn.	*Via* proposed Canal.	Gain.
From England	Miles.	Miles.	Miles.
To Valparaiso	8,700	7500	1200
Callao	10,020	6800	3220
Sandwich Islands	13,500	8640	4860
From New York			
To Valparaiso	8,580	4860	3720
Callao	9,900	3540	5360
Sandwich Islands	13,200	6300	6900

(E. G. S.)

NICASTRO, a town of Naples, province of Calabria Ultra II., on a slope of the Apennines, 19 miles S. by E. of Cosenza. It is meanly built, but walled, and defended by a castle, in which Henry, eldest son of the Emperor Frederick II., was confined for having embraced the Guelph party against his father. The town is the see of a bishop, contains several churches and convents, and has some trade in oil. Pop. 6600.

NICCOLO PISANO, or Di Pisa. See Pisano.

Nice.

NICE (Ital. *Nizza*, anc. *Nicæa*), a seaport-town of the Sardinian States, capital of the province and administrative division of the same name, is built on a small plain between the Alps and the Mediterranean, 96 miles S. by W. of Turin. It is traversed by the River Paglione, and consists of three parts, one of which, called the Quartier de la Croix de Marbre, stands to the W. of the Paglione, and is the principal residence of strangers in Nice. This part of the town derives its name from a marble cross, built here to commemorate the reconciliation of Charles V. and Francis I. in 1538, through the intervention of Pope Paul III. Near this cross stands an obelisk in memory of the two visits of Pius VII. in 1809 and 1814. In this quarter of Nice there is also a large public square, surrounded with fine buildings, and a handsome quay, which runs along the side of the river. The other two parts of the town stand on the E. side of the Paglione, and are separated from each other by a hill of limestone 800 feet high, which formerly had a castle on the summit, but is now laid out in public walks commanding a wide and beautiful prospect. Between the river and the castle-hill is the old town, consisting of several streets of no great breadth, and including, close under the hill, a dirty locality, which is the oldest part of the whole town. The quarter of the port on the other side of the castle-hill is chiefly inhabited by seafaring people, and was once a mean and crowded place, but it has recently been much improved. The harbour is small, but capable of admitting vessels drawing 15 feet of water, and is protected by two moles, one of which has at its extremity a lighthouse and battery. The entrance is difficult in stormy weather, and it is not well adapted for a harbour of refuge. The public buildings of Nice are by no means remarkable; the principal is the cathedral, an edifice in the common Italian style of the seventeenth century. There are numerous other churches, but none of them are of any great architectural merit. The national college (which has a botanic garden), the public library and zoological museum, the theatre, baths, convents, and hospitals, complete the list of the important public institutions of the town. The climate of Nice has been much praised, and although its advantages may perhaps have been exaggerated, there can be no doubt that it is remarkable for its mildness and salubrity. It is subject to no sudden variations of temperature; the changes of season occur with considerable regularity, and the differences in heat from one month to another rarely exceed 2° or 3° Fahrenheit. The mean temperature of the spring at Nice is about 64°; of the summer, about 74°; of the autumn, about 55°; and of the winter, about 50°; while the greatest heat in summer is rarely above 84°, and the cold in winter seldom below 32°. The clearness of the atmosphere during the most part of the year is one of the greatest advantages of the place; but the cold blasts of the *vent de bise*, as it is called, which prevails in February, are both disagreeable and injurious to invalids. The town contains several silk, cotton, paper, and oil mills; and there are also manufactories of tobacco, snuff, perfumery, soap, leather, &c. The trade of the place is in these articles, and in wine, oranges, and other fruits. The number of vessels that entered the port in 1846 was 2609; tonnage, 155,764: those that cleared in the same year, 2583; tonnage, 153,635. Nice was originally founded by the Phocæans of Marseilles, and fortified by them against the native Gallic tribes. For a long time it remained subject to its parent city; and even after both were included in the Roman empire, Nice was still in a subordinate position, and does not seem to have attained to any importance under the Roman sway. The ancient town did not occupy precisely the same site as the modern; but stood further up the mountains, where there are some remains both of this town and of Cemenelium (the modern *Cimies*). In the middle ages Nice was

Nice, Council of.

the capital of a small independent county, and at that time it stood on the left bank of the river, close round the foot of the castle-hill. It afterwards came into the possession, first of the counts of Provence, and then of the kings of Naples; and was sold in the end of the fourteenth century by Ladislaus to Amadeus VII. of Savoy, in whose house it still remains. The town has been taken several times by the French, and was annexed by them to the republic, and made the capital of the department of the Maritime Alps in 1791; but it was restored to Sardinia in 1814.

The administrative division, of which Nice is the capital, is bounded on the N. by Piedmont, from which it is separated by the Alps; E. by the division of Genoa; S. by the Mediterranean; and W. by France. The higher parts of the mountains in the north are covered with forests of excellent timber trees, and the lower slopes and valleys, though unfit for cultivation, afford excellent pasturage. Towards the south the soil is fertile, and produces maize, barley, and wheat; besides olives, figs, grapes, oranges, and other fruits. Cattle are reared to a considerable extent; bees are also kept; and there are good fisheries along the coast. The climate is mild and dry, being sheltered from the north winds by the Alps. It is divided into three provinces, as follows:—

	Area in sq. miles.	Pop. in 1848.
Nice	1178	118,377
Oneille	173	60,072
St Rémo	263	64,541
Total	1614	242,990

The town of Nice is remarkable as the birth-place of Massena, one of the most famous of Napoleon's generals. Pop. 33,811.

NICE, or *Nicæa, The Council of*, was the earliest as well as the most important of the œcumenical councils held in the Christian church. It was convened at Nicæa, a town in Bithynia, A.D. 325, by command of the Emperor Constantine, to settle the controversy which had recently sprung up in the church respecting the doctrines of Arius, presbyter of the Church of Alexandria. In an assembly of the presbyters held some time previously, Alexander, Bishop of Alexandria, maintained that the Son was not only equal in dignity with the Father, but was also of the same essence. Arius charged the doctrine with Sabellianism, and boldly assumed the opposite extreme. "If," said he, "the Father begat the Son, the begotten had a beginning of existence; hence it is plain, that there was a time when he was not." (Socrates, *Hist. Eccles.*, lib. i., c. 5.) Not a few openly sided with Arius; and the upshot of it was that the heretic had his doctrines condemned, and himself and nine of his adherents excommunicated. The quarrel raged fiercely on both sides, and the emperor mildly attempted a reconciliation between the orthodox bishop and the heretical presbyter. His efforts proved unavailing, and in order effectually to silence the disputants, he convened the council in question. Bishops flocked to it from all parts of Christendom, particularly from the East, until their number amounted to 318. The assembly was honoured by the imperial presence; and the venerable Fathers began by accusing each other. Constantine, who seems to have displayed much good sense on the occasion, magnanimously burnt these accusations without reading them; and exhorting the disputants to peace and harmony, bade them open deliberations. Debate waxed keen; words ran high; whole quivers of logic and treasures of learning were exhausted; but unanimity was as distant as ever. The orthodox party, after selecting those passages of Scripture which bear upon the divinity of the Son of God, extracted from them the conclusion that the Son was of *the same substance* (ὁμοούσιος) or consubstantial with the Father. Eusebius of Nicomedia proposed a creed in behalf of the Arians, but the council pronounced it heretical, and appointed Hosius of Corduba to draw up one in its stead. This document, agreeing substantially with the Nicene Creed of the present day, received the sanction of the council and the approbation of the emperor. Deposition, excommunication, and exile were the penalty of non-acquiescence. Arius stood firm, and suffered the consequences. Twenty of the twenty-two Arian bishops, whose ingenuity was nicer than their conscience, subscribed to the creed, by foisting an iota into the Platonic epithet of their opponents, and thus converting ὁμοούσιος (of the *same* substance) into ὁμοιούσιος (of *similar* substance). Secundus of Ptolemais and Theonas of Marmarica declined to stoop to such courtly duplicity, and boldly reproved Eusebius for his dishonesty.[1] (See ARIUS.)

Nice, Council of.

The *Nicene Creed*, as at present recited in the communion service of the Church of England, agrees precisely with the creed drawn up at this council, with the exception of the part which asserts the divinity of the Holy Ghost. This addition was made, A.D. 381, at the council of Constantinople; and the words "and the Son," coming after "who proceedeth from the Father," were inserted by the Spanish bishops in A.D. 447, and admitted after some hesitation by those of Rome in A.D. 883.

The *Second Council of Nice* was held by the Empress Irene and her son Constantine in A.D. 787, and declared the worship of images to be lawful.

(See *The Greek Ecclesiastical Historians of the first Six Centuries of the Christian Era*, 6 vols., London, 1853; *Some Account of the Council of Nicæa*, by John Kaye, D.D., London, 1853; Gieseler's *Ecclesiastical History*,

[1] New and interesting information respecting the Council of Nice has recently been fallen upon in a Syrian fragment in the British Museum (Add. MSS., No. 14,528), written in A.D. 501, and obtained from the Nitrian Desert in Egypt a few years since. The Syrian text of this fragment, with a translation and notes, and some account of the MS. volume from which it has been obtained, was published, under the title *Analecta Nicæna*, by B. Harris Cowper, London and Edinburgh, 1857; but the impression was limited to 250 copies. Among other curious pieces printed in this tract are,—(1.) The Epistle of Constantine the King summoning the Bishops to Nice, referred to by Eusebius in his Life of that monarch, but hitherto regarded as lost; (2.) The Decree of Constantine against the Arians, given by Socrates in his Church History, and found in other Syrian MSS.; (3.) The Nicene Creed; (4.) The Creed of Constantinople; (5.) The Subscribers to the Nicene Council, the most ancient, curious, and complete list yet brought to light; (6.) Titles of the Canons of Nice; (7.) The Colophon; (8 and 9.) Fragments from another MS. in the same collection, in which the presidency of the Nicene Council seems to be assigned to Alexander of Alexandria; (10 and 11.) Canons VI. and VII. of the Nicene Council, from which it will be seen, that no allusion whatever is made to any superiority of the Roman See different from that of the others mentioned; (12.) Colophon. The following is a copy of the long-lost letter of Constantine, as translated by Mr Cowper:—"*An Epistle of Constantine the King, summoning the Bishops from Ancyra to Nice.*—That there is nothing more honourable in my sight than religion, is, I believe, manifest to every man. Now, because the Synod of Bishops at Ancyra, of Galatia, consented formerly that it should be so, it hath seemed to us now on many accounts, that it would be well for it to be assembled at Nice, a city of Bithynia, because the Bishops of Italy, and of the rest of the countries of Europe, are coming, and because of the excellent temperature of the air, and because I shall be at hand as a spectator and participator of what is done. Wherefore I signify to you my beloved brethren, that ye, all of you, promptly assemble at the city I spoke of; that is, at Nice. Let every one of you, therefore, diligently inquire into that which is profitable, in order that, as I before said, without any delay we may speedily come to be a present spectator of those things which are done by the same. God keep you, my beloved brethren." (P. 21.)

Nicephorus.

Edinburgh, 1846; Neander's *History of the Church*, 8 vols., London, 1850–52; and Landon's *Manual of Councils*.)

NICEPHORUS I., Emperor of Constantinople, was a native of Seleucia, and rose by the favour of the Empress Irene, and by his own hypocritical intrigues, to the high office of *logotheta*, or minister of finances. In 802 A.D., assisted by the ungrateful treachery of some eunuchs who were high in favour with the queen, he seized upon the purple. After Nicephorus had consolidated his power by the most cruel measures, he despatched a letter to the caliph Harun-al-Raschid, demanding back the tribute-money paid him by the Empress Irene. The caliph replied by devastating the plains of Phrygia; and, after various fortune, the death of Harun-al-Raschid in 809, left Nicephorus to direct a system of universal butchery against the Bulgarians. He was surprised and slain in 811. (See CONSTANTINOPOLITAN HISTORY.)

NICEPHORUS II., surnamed *Phocas*, Emperor of Constantinople, was the descendant of a warlike race, and was born about 912 A.D. He was brought up in the camp, and rose by his own merit through the different grades of promotion until he was appointed *magnus domesticus* in 954. His military genius was first displayed in several expeditions against the Saracens during 956 and 958; but not until 959 did it appear in its full splendour. He then proposed to the young emperor Romanus II. the bold design of taking Crete, which had been for more than a hundred years the impregnable stronghold of a desperate gang of Arabian pirates. The enterprise received the approval of the emperor; and in 960 Nicephorus was laying vigorous siege to the massive fortifications of Candia, the capital of the Cretans. Complete success was achieved in the following year. He captured the city, and along with it the whole island; the inhabitants yielded to his proselytizing zeal, and received baptism; and the long-extinct honours of a triumph were revived to reward him on his return to Constantinople. But in the full enjoyment of his renown, the conqueror did not forget to follow up his success. Setting out at the head of a mighty army in 962, he forced his way through the narrow passes of Mount Amanus, and entering Syria, compelled the principal cities to throw open their gates. He was advancing in his career of victory towards the River Euphrates, when intelligence reached him, in 963, of the death of the Emperor Romanus. The thought of aspiring to the vacant throne now seized him, and changed the generous and free-hearted warrior into the wily votary of ambition. His designs were executed with a soldier-like promptness and decision. He first procured for himself the appointment to the supreme command of the oriental armies during the minority of the infant princes; then he gained over to his interest the officers and soldiers; and at length he married the deceased emperor's wife—the infamous Theophano—and assumed the title of Augustus. But Nicephorus was not so popular on the throne as in the camp. Though he reappeared at the head of his armies, and yearly made a successful invasion against the Saracens, yet the heavy taxes which were levied to support these expeditions more than counterbalanced, in the public estimation, the glory gained by them. The emperor came to be generally accused of hypocrisy and avarice. His fickle wife in course of time joined the number of his enemies, and began to plot his death. One of her paramours, John Zimisces, a brave and able general of the imperial armies, was induced to undertake the office of assassin. On a December night in 969, he crossed in a small boat from the Asiatic side of the Bosporus, and was admitted by a rope-ladder into the palace. There a band of cut-throats, putting themselves under his direction, burst into the royal apartment, and murdered Nicephorus as he started from sleep. The arch-assassin immediately afterwards married Theophano, and succeeded to the purple.

NICEPHORUS III., surnamed *Batoniates*, Emperor of Constantinople, claimed to be a descendant of the Roman Fabii. He served in the imperial forces, and in 1078 had risen to be commander of the army in Asia. In that year, aided by the Sultan Soliman, he raised the standard of revolt against the Emperor Michael VII. The discontented populace of Constantinople received him with enthusiasm; the weak emperor resigned his crown to retire into a monastery; and Nicephorus ascended the throne on the 25th March 1078. The new reign was inaugurated with a cruel and narrow-minded policy which soon brought it to a close. The rebel generals Ursel, Bryennius, and Basilacius, who were soon afterwards defeated and captured, had their eyes put out, and were reserved for further cruelties. Even the brave Alexis Comnenus, the conqueror of these, became at length the object of the emperor's ever-wakeful suspicions, and was forced to flee from the ungrateful court. It was this injustice that caused the downfall of Nicephorus. Alexis was proclaimed emperor by the indignant soldiery, and Nicephorus, resigning the crown retired to end his days in a monastery.

Nicephorus ‖ Nicolas

NICEPHORUS *Callistus*, an ecclesiastical historian, was born towards the close of the thirteenth century, and died about 1350. In his thirty-sixth year he was engaged at Constantinople in the composition of an *Historia Ecclesiastica*, founded on the narratives of Eusebius, Socrates, Sozomen, Theodoret, Evagrius, and others. It is filled with absurd fables; and of the twenty-three books only eighteen are extant. They were published in Greek and Latin, in 3 vols. fol., Paris, 1630.

NICEPHORUS, Patriarch of Constantinople, was the son of Theodorus, one of the imperial secretaries of Constantius Copronymus, and was born in 758. From his father he inherited a zeal for image-worship, which gave a colour to all the principal events of his life. He was present as imperial commissary at the Nicene Council of 787, and raised his voice against the Iconoclasts. This spirit of partizanship only became more intense when, in 806, he was raised from the condition of a monk to the patriarchate of Constantinople. An edict against the worship of images was passed in 814 by Leo the Armenian; but neither entreaties nor menaces could prevail upon Nicephorus to assent to it. He rather preferred to be deposed in the following year, and to spend the rest of his days in a convent. His death took place in June 828. Of his works, which are written in Greek, the best is his *Breviarium Historicum*, a compendious history of the period extending between 602 A.D. and 770. It was published, with a Latin version and notes, in 8vo, Paris, 1616; and was reprinted in the *Corpus Historiæ Byzantinæ*. A Life of the Patriarch Nicephorus, by his contemporary Ignatius, has been translated into Latin, and inserted in the *Acta Sanctorum*.

NICHOLAS I., the earliest of the Roman pontiffs who bore that name, was elevated from the rank of a deacon to the papal chair in April 858. One of his first endeavours was to realize the alleged supremacy of the popedom. Assuming as his authority the new ecclesiastical code, now known by the name of the Pseudo-Isidorian Decretals, he asserted that the Pope, as the representative of St Peter, was the head of Christ's body the church; that the bishops, as members of that body, had no other law than his will; and that all offences throughout Christendom should be liable to be arraigned before his tribunal. These principles, so boldly asserted, were as boldly carried into practice. Taking part in the dispute concerning the patriarchate of Constantinople between Ignatius and Photius, he excommunicated the latter in 863, and maintained a fierce controversy with the Emperor Michael III. in support of this exercise of his ecclesiastical authority. He also interfered, during the same year, with the attempt of Lotharius, King

Nicholas. of Lotharingia, to divorce his wife Thietberga, and to marry his concubine Waldrade. The Emperor Louis, the brother of Lotharius, bent upon forcing Nicholas to withdraw his interference, marched into Rome at the head of an army. But the fervent and long-continued devotions and the saint-like composure of the Pope soon awed the superstitious potentate into submission and reconciliation. Nicholas continued for the rest of his life to vindicate successfully the absolute ecclesiastical supremacy of the see of Rome. He died in 867. His letters, amounting to about a hundred, and treating of church doctrine and discipline, were published in folio, Rome, 1542. The rest of his works were inserted in Coleti's *Collection of Councils*.

NICHOLAS II., whose original name was Gerhard, was promoted from the bishopric of Florence to the Papal chair in 1058. Under the guidance of the able and ambitious Hildebrand, who was afterwards supreme pontiff under the title of Gregory VII., he proceeded to establish his authority, and to provide for the increased stability and influence of the Papal see. John, bishop of Velletri, who had been set up as a rival Pope, under the name of Benedict X., was forced to submit. A law was passed in 1059 which took the power of choosing the supreme pontiff out of the hands of the Roman mob, placed it in the hands of the cardinal bishops and priests, and restricted the elective influence of the emperor and the citizens of Rome to a mere assent. The new Pope was even daring enough to claim the possession of Apulia, Calabria, and Sicily, to give them in fief to Robert Guiscard, a Norman, and thus to establish the civil supremacy of the Roman see over that territory which was afterwards known as the kingdom of Naples. Nicholas was further engaged in enforcing a stricter morality upon the priests, when he died in July 1061.

NICHOLAS III., whose original name was Giovanni Gætani, succeeded John XXI. in 1277. His descent from the noble family of the Orsini, his tact, and his energy rendered him a powerful upholder of the despotism of the Roman see. He obtained from the Emperor Rudolph several grants of territory in Italy, and punished the haughty insubordination of Charles of Anjou, King of Naples, by depriving him of the dignity of senator of Rome. Other great projects were occupying his attention, when a stroke of apoplexy brought his career to a close in 1280.

NICHOLAS IV., originally known by the name of Jerome of Ascoli, was raised from the bishopric of Palæstrina to the pontifical chair in 1288. Though sometimes guilty of favouritism, he was characterized in general by an enlightened zeal for the welfare of the church. He was a liberal patron of theological as well as civil learning; he sent forth missionaries as far as China; and he used his utmost efforts to revive the spirit of the Crusades. It is said to have been the final expulsion of the Christians from the Holy Land that hastened his death in 1292.

NICHOLAS V., whose real name was Tommaso Da Sarzana, succeeded Eugenius IV. in 1447. The meek probity of his character did not suffer him to adopt the usual aggressive policy of the popedom; and his literary tastes induced him to seek for that general peace which is so favourable to the advancement of learning and civilization. The consequence was, that in 1449 the anti-Pope Felix V., who had for several years maintained a schism in the church, tendered his submission; and about the same time the Italian states, discontinuing their accustomed broils, relapsed into tranquillity. The learned pontiff was thus enabled to devote the rest of his life to the promotion of polite letters. Under his rule Rome became the favourite seat of learning. The most liberal patronage was extended to literary merit; wits and scholars from all parts of Europe thronged the pontifical court; a library, containing famous manuscripts of the Christian fathers and the great Greek authors, began to be formed in the Vatican; and messengers were constantly arriving from all the countries of Christendom with new treasures for its shelves. This rapid advance towards general enlightenment was prematurely interrupted by the death of its wise and munificent promoter in 1455. Nicholas, St ‖ Nicias.

NICHOLAS, ST, one of the Cape Verde Islands, is situated in N. Lat. 16. 42., W. Long. 24.20. Its shape is irregular; and its area is 115 square miles. There are two remarkable mountains in the island, one of which, near the centre, has the form of a sugar-loaf, and is called the Peak of Trade. The soil is fertile, but there is not much wood or water. There are several not very good harbours on the south coast; but the principal trade is carried on at Grand or St George Bay, at the western extremity. Pop. 5418.

NICHOLS, JOHN, a writer of literary anecdotes, was born at Islington in 1745, and at the age of twelve became an apprentice to the famous printer William Bowyer. His taste for literature, his industry, and his business talents soon raised him high in the favour of his master. He was taken into partnership in 1766, and succeeded to the entire business in 1777. It was then that the aptitude for curious biographical and topographical research by which he was specially characterized began to appear to the world. In course of time it found full scope in the *Gentleman's Magazine*, of which he became editor and part proprietor in 1778; in his *History of Leicestershire*, which he began in 1795, and completed in 4 vols. fol. in 1815; and in a series of rare literary and antiquarian works which he continued to edit and print. But its chief result was the *Literary Anecdotes of the Eighteenth Century*, in 9 vols. 8vo, 1812–15. This work was a rich biographical treasury, containing numerous traits of eminent men of every stamp, and much correspondence, judiciously selected and accurately given. But Nichols had not yet exhausted his stock of this sort of historical materials. In 1817–22, he published *Literary Illustrations of the Eighteenth Century, intended as a Sequel to the Literary Anecdotes*, in 4 vols. A fifth volume was in the press, and a sixth in preparation, when the author died in 1826. The former was published in 1828, and the latter in 1831. A seventh volume appeared in 1848, and an eighth in 1858, both by his son, John Bowyer Nichols, who succeeded to his father's business. (See *Gentleman's Magazine* for 1826.)

NICHOLSON, WILLIAM, an eminent chemist and mechanician, was born in London in 1753. His early years were spent in commercial pursuits, but he soon abandoned that occupation for the more congenial walk of scientific research. He opened a school in the metropolis in 1775, which he continued to conduct with great success for a long series of years. Meanwhile he prosecuted mechanical invention and scientific inquiry with great zeal. Besides English translations of the chemical works of Fourcroy, Chaptal, &c., he wrote numerous treatises on natural philosophy and chemistry, and was unquestionably the most eminent philosophical journalist of his day. His most valued works are his *Dictionary of Chemistry*, 2 vols. 4to, 1795; and his *Journal of Natural Philosophy, Chemistry, and the Arts*, 5 vols. 4to, 1797–1802, of which a new series appeared in 36 vols. 8vo, 1802–14. He invented an aræometer and other instruments, but so impoverished himself by these pursuits that he was imprisoned for debt. He died in London in June 1815. (See DISSERT. SIXTH, chap. vii.)

NICIAS, an Athenian statesman, son of Niceratus, chosen by the aristocracy and the more moderate of the democratical party, as the fittest person to lead the councils of the commonwealth after the death of Pericles, in 428 B.C. He was also a favourite with the people, as he was liberal of his wealth for their gratification, and ever ready to assist the distressed. He resembled Pericles in the conservative nature of his foreign policy, and in the thorough incorruptibility of his character. The rigid decorum and strict devout-

Nicias. ness of his character have been severely ridiculed by Aristophanes, in the *Equites*, as nothing better than timidity and superstition. The first matter in which Nicias and Cleon took opposite views was the punishment that ought to be inflicted on the inhabitants of Mitylene for their rebellion. Cleon proposed and carried a decree for putting every man to death, and for reducing the women and children to slavery. This monstrous proposition was opposed by all the influence of Nicias, but passed in spite of its evident injustice. Nicias led several expeditions, and was always successful, because, as Plutarch says, he selected those commands where success was nearly certain, although the glory might indeed be small. He took the islet called Minoa, at the mouth of the harbour of Nisæa, the seaport of Megara; and he plundered the coast of Bœotia. He commanded the fleet, 425 B.C., at the time that the island Sphacteria was blockaded by the Athenians, and willingly gave up the command to Cleon, who exclaimed that if he were in that station he would engage to subdue the island within twenty days, and bring the garrison prisoners to Athens. To the great surprise of all parties, Cleon succeeded in the enterprise (Thucydides, iv. 28). The following year we find Nicias commanding an expedition, which was directed against the island of Cythera, an important appendage of the Lacædemonian territory, and which Nicias took without much difficulty. After the death of Cleon at Amphipolis, 422 B.C., there was a strong inclination on both sides to bring the war to a close; and as Nicias was the most active in promoting the measure, it was usually called the Niceian peace. The fundamental principle of the treaty was, that each party should restore what had been taken in war, except that Nisæa was reserved to Athens, in consideration of the refusal of the Thebans to surrender Platæa. It was concluded for fifty years, 421 B.C. (Thucydides, v. 18.) At this time Alcibiades began to occupy himself with public affairs; and wishing to ingratiate himself with the popular party, he took the opposite side to Nicias in almost every question. It was so in respect to the peace; and as there were some articles liable to be disputed, Alcibiades soon managed to embroil matters, and war again broke forth in all its original fury, 418 B.C. An expedition to Sicily was next proposed by Alcibiades; and although it was strongly opposed by Nicias, the decree was passed, and Nicias was appointed, along with Lamachus and Alcibiades, 415 B.C., to command the troops. Matters were conducted with various success; but the Athenians were at length completely defeated, and Nicias fell into the hands of the Syracusans. The mob demanded his life; and although Gylippus, the Syracusan general, exerted himself to save Nicias, it was without success. When Nicias and his colleague Demosthenes heard the sentence which had been passed against them, they anticipated their fate by putting themselves to death, in the year 413 B.C. (Thucydides, vii.; Plutarch; Diodorus Siculus; Thirlwall's *History of Greece*, vol. iii.; Grote's *History of Greece*, vols. vi., vii.)

NICIAS, a great Greek painter, was the son of Nicomedes, and flourished at Athens about the fourth century B.C. He studied his art under Antidotus, a pupil of the celebrated Euphranor. One of his earliest undertakings seems to have been the painting of the marble statues of Praxiteles, a process which the Romans called *circumlitio*. But, though eminently successful in this engagement, he soon turned his hand to the more legitimate branches of his art. All his energies became absorbed in the executing of pictures. He devoted great attention to colouring, and was the first painter who used burnt ochre; he studied the subjects of his pieces with the minute care which the dramatic poet bestows upon his plot; and he was often so engrossed with his work that he forgot to take his meals. The result of such painstaking industry was, that the artist soon grew famous for the graceful design, the beautiful colouring, the exquisite light and shade and the fine general effect of his pictures. His masterpiece was entitled Νεκυία, and was a representation of the infernal regions taken from the description in the Odyssey. Ptolemy, King of Egypt, offered sixty talents for it; but the painter chose rather to present it to his native Athens. Such a patriotic liberality seems to have combined with his genius in gaining for him the esteem of his fellow-citizens; for, at his decease, he was honoured with a public funeral, and was interred in the cemetery consecrated to the great Athenian dead, on the road between the city and the academy. Nicobars ‖ Nicolai.

The other important works of Nicias, as enumerated by Pliny, were a Nemea, a Hyacinthus, a Bacchus, and an Alexander (Paris), all at Rome. (A minute account of Nicias is given in the *English Cyclopædia*.)

NICOBARS, a cluster of islands in the Indian Ocean, lying between N. Lat. 6. 40. and 9. 20., and E. Long. 93. 3. and 94. 13., and inhabited by Malays. A settlement was formed here by the Danes in 1756, but abandoned by them in 1768. In the year 1840 the whaler Pilot, of London, was seized by pirates infesting the Nicobars. At this period the sovereignty of these islands was claimed by the Danes. Evidence subsequently obtained, left little room for doubt, that, in several instances, the crews of British vessels had been murdered, and the vessels scuttled and sunk by the islanders. Measures were taken to give notoriety to these circumstances. In 1848 the Danish government came to the determination to abandon all claim to sovereignty over the Nicobars. Some years later, certain residents of Chittagong made a representation to the Indian government regarding two brigs which had sailed for the Nicobars in the year 1852. Neither of them had since been heard of, and a strong presumption existed that both had been cut off by savages. Captain Dicey, of the steamer Tenasserim, was therefore despatched to the Nicobars for the purpose of inquiring into the fate of the missing vessels; and the report of this officer, the official authorities observes, "leaves no doubt that two vessels, one of them English, have recently been destroyed, and their crews murdered by the inhabitants of the Nicobars; and there seems too much reason to fear that these atrocities have been preceded by many similar outrages." These and the adjacent islands, the Andamans, would, it has been suggested, answer admirably for a convict settlement.

NICOLAI, CHRISTOPH FRIEDRICH, a German author, was the son of a bookseller, and was born at Berlin in March 1733. The intense ardour for learning which characterized his life was early shown. Though engaged so soon as his sixteenth year in the bookselling trade, he made himself a proficient in general literature, and in the Greek, Latin, and English languages. His increasing devotion to letters led him in 1757 to resign his partnership in the family firm; and though he was recalled to business in the following year by the death of his brother, yet the projects that he had planned during his retirement were actively carried out. By this time he had formed, in conjunction with Lessing and Moses Mendelssohn, a literary triumvirate, for the purpose of founding a new school of German criticism. They had begun their scheme in 1757, by publishing the *Bibliothek der Schönen Wissenschaften*. They now continued it in 1759 by giving to the world the first of their famous *Letters on Criticism*. It was with a similar end in view that in 1765 Nicolai became the projector and editor of the influential periodical styled *Allgemeine Deutsche Bibliothek*. The severe and prosaic tone of criticism which characterized this work soon involved him in many disputes with some of the greatest writers in Germany. His facile and ever-active pen was especially employed in writing pamphlets and satirical romances against the philosophy of Kant. Fichte and A. W. Schlegel attacked him in turn. Yet the

Nicolaitans || Nicolas.

irascible Nicolai continued to wrangle with his numerous enemies, and at the same time to dabble in all sorts of subjects, till his death in 1811. His Life was published by Göckingk in 8vo, Berlin, 1820.

NICOLAITANS, a Gnostic sect of the second century, mentioned by Irenæus, Tertullian, and Clement of Alexandria. They claimed to have been founded by Nicolas, one of the seven deacons enumerated in the sixth chapter of the Acts; and they were believed by the early fathers to be identical with the sect of the same name alluded to in the second chapter of the Apocalypse. But neither of these opinions rests on satisfactory grounds. The peculiar tenets of the Nicolaitans were founded on the principle that the passions ought to be allowed to exhaust and destroy themselves by indulgence. "Subdue the flesh by abusing it" was the favourite motto with which they justified their licentious conduct. (Neander's *Church History.*)

NICOLAS, Sir Nicholas Harris, a very eminent English antiquary, was the fourth son of John Harris Nicolas of East Looe in Cornwall, whose Breton ancestors had settled there on the revocation of the edict of Nantes. He was born on the 10th March 1799. He entered the navy on the 27th October 1808; and after some years of active service as midshipman under his brother, in which he took part in the capture of several armed vessels and convoys on the coast of Calabria, he was promoted to the rank of lieutenant on the 20th September 1815. Not succeeding at the close of the war in obtaining employment, he left the service, and took to the study of English law and antiquarian literature. His first work, *The Life of Secretary Davison*, appeared in 1823, the author having married a descendant of the family of that worthy privy counsellor during the previous year. He was called to the bar by the society of the Inner Temple in 1825, but his practice never extended beyond the occasional claims of peerage before the House of Lords. Nicolas was chosen shortly afterwards a Fellow of the Society of Antiquaries, became a member of their council in 1826, and was a frequent and valuable contributor to the *Archæologia*. His imprudent zeal and violent temper, however, did not permit him long to enjoy this dignity; for after his first appearance at its deliberations, the society struck him off their list. He thereupon commenced a series of attacks against the administration of the affairs of the society, which do not seem to have been in the most perfect state possible. These animadversions, besides appearing in pamphlets, found a frequent place in the pages of the *Retrospective Review*, of which Nicolas had become joint editor in 1826. He continued with incredible industry to elucidate and illustrate various departments of history, genealogy, and heraldry, in a series of works, displaying great research and sound critical acumen. As a whole, his works possess a substantial historical value; but those perhaps in which he has placed the majority of writers under the greatest obligations to his industry and acuteness, are the *Synopsis of the Peerage of England*, 2 vols., 1825; the *Testamenta Vetusta*, 2 vols., 1826; and his *Chronology of History*, a work of great value, written in 1835 for Lardner's *Cyclopædia*, and remodelled from his *Notitia Historica* of 1824. In his *Controversy between Sir Richard Scrope and Sir Robert Grosvenor*, 2 vols., 1832, a work which was never completed, and in his *Siege of Caerlaverock*, there occur a number of highly valuable biographical notices; and, among others, one of Geoffrey Chaucer, which the author afterwards enlarged for Pickering's Aldine edition of that poet. For the same series of British poetical authors, Nicolas wrote the memoirs of Surrey, Wyatt, Collins, Cowper, Thomson, Burns, and Kirke White. In connection with the same field, he made some curious and successful explorations in his *Lives of Isaak Walton and Charles Cotton*, prefixed to Pickering's beautiful edition of *The Complete Angler*. His greatest works, however, and those by which his name will be longest remembered by the majority of readers, are the *History of the Orders of Knighthood of the British Empire*, four large 4to vols., 1841–42; and *The Dispatches and Letters of Admiral Lord Viscount Nelson*, 7 vols. 8vo, 1844–46. In acknowledgment of his merits in connection with the former work, he was made a knight of the Hanoverian Guelphic Order in 1831, was appointed chancellor of the Ionian Order of St Michael and St George in 1832, and was advanced to the grade of Grand Cross by Her Majesty in 1840. Sir Harris left an unfinished *History of the British Navy*, in 2 vols., which promised to be a work of very great merit. He was engaged in editing the papers of Sir Hudson Lowe, until within a few days of his death, which took place at Cape Curé, near Boulogne, August 3, 1848. (See *Gentleman's Magazine* for October 1848, which contains a complete list of his writings; and *Athenæum* for August 12, 1848.)

Nicolas || Nicole.

Nicolas I., *Pavlovich*, Emperor of Russia, was the third son of the Emperor Paul, and was born at St Petersburg on the 7th of July 1796. He succeeded his eldest brother, Alexander I., on the 1st of December 1825, and was crowned at Moscow on the 3d September 1826. He declared war against the Shah of Persia in this latter year, incorporated the kingdom of Poland with his own empire in 1832, commenced a war with Turkey in 1853, which brought against him the allied armies of England and France in 1854, and died on the 2d March 1855, leaving his throne to his eldest son, the present Emperor Alexander II. (See Russia.)

NICOLAS, or Nicholas, St, a town of Belgium, in the province of East Flanders, is the principal place in the populous and well-cultivated district called the Pays de Wâes, 20 miles N.E. of Ghent. It is well built, with broad and regular streets, and a spacious market-place, surrounded with fine houses. There are several churches, one of which, that of St Nicholas, is a handsome structure; a town-hall, a college, several schools, an hospital, two orphan asylums, and a prison. Among the manufactories of the town, tanneries, breweries, distilleries, salt-refineries, dye-works, and potteries are the chief; and in addition to these, linen, cotton, woollen, and silken stuffs, carpets, lace, hats, tobacco, chocolate, earthenware, &c., are manufactured. In corn, flax, hemp, linen, &c., an active trade is carried on; and a market for flax is held here which is said to be the largest in the world. Pop. 20,500.

NICOLAUS, surnamed *Myrepsus*, or "the ointment-maker," the author of a Greek pharmaceutical work, flourished in the thirteenth century at the court of the Emperor John III. His treatise is known to the public only in the form of a Latin translation entitled *De Compositione Medicamentorum*. Its value is almost cancelled by the fact that it places the most absurd monkish charms and talismans in the category of remedies, and is little else than a compilation from Nicolaus Præpositus, and other medical writers. Yet it has found a place in the second volume of H. Stephens's *Medicæ Artis Principes*, fol., Paris, 1567, and has since been reprinted.

Nicolaus, surnamed Præpositus to distinguish him from Nicolaus Myrepsus, was the author of a Latin pharmaceutical work entitled *Antidotarium*, and flourished in the former half of the twelfth century as the principal of the medical school at Salerno. His book was a standard authority during the dark ages, was first printed at Venice in 1471, and has frequently been republished.

Nicolaus Damascenus. See Damascenus, *Nicolaus*.

NICOLE, Pierre, one of the most illustrious of the Port-Royalists, was born at Chartres on the 19th October 1625. His father, Jean Nicole, who was a parliamentary advocate, succeeded early in imbuing the mind of his son with not a little of his own taste for classical literature. At

Nicole. the age of fourteen this grave and studious boy had completed his preliminary studies; and his father removed him to Paris, where, in 1644, he finished a course of philosophy and theology, and took his master's degree. The university of Paris was at that time in a ferment touching the celebrated propositions of the Jansenists; and Nicole had his attention turned to the solitaries of Port-Royal. The profound piety of that venerable community, and the austere tranquillity of their life, had strong attractions for a spirit so calm and meditative as that of Nicole, whose only wish was for study and retirement. He accordingly betook himself to their quiet retreat, and divided his time during the three following years between studying the theology of the Sorbonne, and giving instructions in *belles lettres* in the educational institutions of Port-Royal. Having made application for licence, it was discovered that his opinions were not in accordance with those of any Roman Catholic university, much less with those of the theological faculty of Paris, and he resolved to content himself with his theological *baccalauréat*, which he had obtained in 1649. From this period he attached himself more closely to Port-Royal and the Jansenists, and soon after took up his pen, in conjunction with the celebrated Antoine Arnauld, in defence of Jansenius and his doctrines. Nicole never adopted Jansenism, however, in all its extreme rigour. In various treatises written at a comparatively early period of his career, he took exception to not a few of the doctrines of his brethren of Port-Royal, even while he put forth all his strength in behalf of what he regarded as their grand claims upon his fellow-men. This attitude is most noticeable perhaps in a theological dissertation, published by him in 1657, under the pseudonym of Paul Irenæus, designed to pacify the Church, and to prove that Jansenism was only an imaginary heresy. This interesting work bore the title of *Disquisitiones sex Pauli Irenæi ad præsentes Ecclesiæ tumultus sedandos opportunæ*. In 1658 Nicole made a journey into Germany in behalf of the cause; and during his residence there, translated into Latin the famous *Lettres Provinciales*, which had recently issued from the most gifted pen among the Port-Royalists. During the execution of this task, the translator read Terence incessantly, in order to catch the rare pungency and sprightliness of the dramatist, and transfuse it, if possible, into his version of these immortal letters. He submitted his work to the Germans and Dutch as the performance of "William Wendrock, doctor of the University of Salzburg." On his return he retired with Arnauld to Châtillon, near Paris, to devote himself with renewed ardour to the prosecution of his cherished pursuits. One of the earliest products of his pen in this retreat was the part he took in the composition of the celebrated "Port-Royal Logic," published anonymously at Paris in 1662, under the title *La Logique, ou l'Art de Penser;* a work of pre-eminent merit, which stands unrivalled even to the present day as an introduction to the study of the laws of thought.[1] In 1664 Nicole gave Nicole. to the world his well-known *Perpétuité de la Foi*, better known as *La Petite Perpétuité*, which the attempted refutation of Claude induced the author to expand, five years afterwards, into *La Grande Perpétuité*, in 3 vols. 4to. The reputation gained for the humble Port-Royalist by this striking performance proved too much for his modesty, and he was fain to attribute the merit of it to his illustrious friend Arnauld. *Les Visionnaires* (1665–6), directed by Nicole against the absurd mysticism of the poet and romancist Desmarets, called forth a bitter attack from Racine upon his ancient master at Port-Royal. At the urgent request of his friends, Nicole in 1676 again solicited ordination, but found his Port-Royal sympathies too great a barrier for the liberality of the Bishop of Chartres. A *Lettre* which he wrote in 1677, for the bishops of Saint-Pons and Arras, to Pope Innocent XI., on the laxity of the casuists, raised such a storm against him that he was obliged to withdraw from the capital. On the death (in 1679) of the Duchesse de Longueville, the most ardent protectress of Jansenism, Nicole, considering himself as no longer safe in France, left the kingdom, and sought an asylum in the Low Countries. He returned to France in 1683, and after remaining in concealment for some time, ultimately took up his abode at Paris and resumed his literary occupations. It was during this period that he completed his *Essais de Morale*, of which the first four volumes had been given to the public between 1671 and 1678. The last two volumes were published after the author's death, the fifth in 1700, and the sixth in 1714. After *L'Art de Penser*, it is unquestionably on this work that Nicole's reputation as a philosophical writer mainly rests. We search in it in vain, however, for much decided speculative originality. His strength did not lie there. He is mainly occupied with delineations of a moral and religious nature, characterized by exquisite subtilty and discrimination; but he seldom or never permits his thoughts to traverse the decisive circle meted out by his faith. Yet one constantly admires the delicate observation, steady judgment, and calm spirit of the man. Among his moral treatises there is, perhaps, no one more characteristic of the author, and certainly no one superior to *Les Moyens de Conserver la Paix avec les Hommes*. It is only after reading this that one can adequately estimate how great must have been that loyalty to the cause of truth, and devotion to the honourable brotherhood with whom he laboured, which could have induced so gentle a nature to leave the quiet which he loved so well, to do earnest battle in the arena of religious controversy, or to share in the fierce strifes of political partizanship.[2] The repose which his nature longed after he was not destined to find here. "Rest! we shall rest through eternity," said the bright and brave Arnauld to him reproachfully. Nicole's closing years were occupied with two notable controversies,—the one on monastic studies, in which he defended the liberal

[1] The authorship of this famous work was for a long time problematical. It was sometimes ascribed to Nicole, sometimes to Arnauld, and sometimes to both. The latter is the correct opinion, however; for the younger Racine, who was a pupil at Port-Royal, informs us, that the dissertations and additions are by Nicole; the first, second, and third parts by Arnauld and Nicole together; and the fourth by Arnauld alone. (See Barbier's *Dictionnaire des Ouvrages Anonymes Pseudonymes*, Paris, 1806.) After the first draft of the book in 1662, numerous changes and additions were made to it in the editions which were issued during the lifetime of the authors. The fifth edition, from which the endless reprints which followed were taken, was published at Paris in 1683. It was translated into Latin soon after its first appearance; and of the various versions of it in that language there have been a great number of editions. A Spanish translation appeared in 1759, and an Italian one some years previously. There have been three English translations of the *Art of Thinking;* the first by "several hands," in 1685; the second by John Ozell, in 1716; and the third by Thomas Spencer Baynes, in 1851. The latter is an admirable performance, and contains an *Introduction*, in which the scientific position, character, and history of the work are carefully traced.

[2] The simple and ingenuous character of Nicole often manifested itself in extreme timidity and amusing eccentricity. If an objection was raised in a discussion which he had not foreseen, he was entirely disconcerted. "Tréville beats me," he said, "in the chamber; but before he reaches the foot of the stair I confute him." Having resided for a long time in the Faubourg Saint-Marcel, some one asked him why he preferred this locality. "It is," said he, "because the enemies who menace Paris will probably enter by the gate of Saint-Martin, and will accordingly be obliged to traverse the whole city before reaching my place of abode." "When walking in the streets," says the Comtesse de la Rivière, "he was always haunted by the fear that a tile would fall upon his head; and when he travelled by water, he was in perpetual terror lest he should be drowned." (*Lettres de M. L. C. de la Rivière*, Paris, 1776.)

Nicoll ‖ Nicolson.

sentiments of Mabillon; the other on Quietism, in which he took part with Bossuet against Fénélon, but with infinitely more honest manliness and liberality than was displayed by the proud "Eagle of Meaux." The weighty labours of a long life and the repeated excitement of controversy, for which his temper was so little fitted, had in 1693 produced their natural effect upon his health. After a lingering illness of two years he was suddenly struck with apoplexy. Crowds of persons from all quarters of Paris hurried to visit the dying couch of the gentle-hearted pious old man. Young Racine, now at the summit of his great fame, forgot his former animosity to the author of *Les Visionnaires*, and, with a restorative medicine in his hand, hastened to where his old master lay. But it was all in vain; the good man's work was done. He died on the 16th November 1695, at the age of seventy. Contrary to his expressed desire to be interred without ceremony, his remains were accompanied to the grave by the most distinguished men of the time.

The works of Nicole, entitled *Essais de Morale et Instructions Theologiques*, form 25 vols. 12mo, and were published between 1671 and 1714. They were reprinted in 1741–44. Among a number of minor performances not already mentioned, there is a *Vie de Nicole* by the Abbé Goujet, forming the 14th vol. of the series. A Life of Nicole will also be found in Besoigne's *Histoire de Port-Royal*, vol. iv.; and another by Saverien, in his *Vies des Philosophes Modernes*, vol. i. The *rôle* of Nicole at Port-Royal, and his dissent from certain positions of Pascal charged with scepticism, have been placed in a clear light by Victor Cousin in the *Revue des Deux Mondes* for January 1845. On the opposite side, see Flottes' *Etudes sur Pascal*, 1846.

NICOLL, Robert, a Scottish poet, was born in the parish of Auchtergaven, in Perthshire, on the 7th of January 1814. His parents were too poor to give him a regular education; but his mother, who was a woman of singular energy and intelligence, snatched an occasional hour when her day of field-labour was done to teach her boy to read. His school education was of the most rudimentary character; but by industry and courage he strove to supply the deficiency. At the age of eight we find him tending cattle for a livelihood, and eagerly reading books. When he was thirteen, he could write an occasional paragraph for a local newspaper; and when bordering on twenty, he had completed his apprenticeship with a grocer and wine-merchant in Perth, and was known as a writer of tales, poems, and songs. In 1834 he opened a small circulating library in Dundee, and during the following year published a volume of *Poems and Lyrics*, which was very favourably received by the press, and soon passed through three editions. His verses, without being characterized by any of the highest qualities of poetry, display great sweetness, purity, and tenderness, and breathe much of the joyous hopeful valour of his life. In 1836 his strongly liberal sentiments got full vent in the pages of the *Leeds Times*, an ultra-radical journal, of which he had become editor. The spirit, energy, and devotion, with which he entered upon this new undertaking, soon tripled the circulation of the paper, but broke the health of the brave young poet. He had been little more than a year in this position when he was compelled to leave it. He died of consumption, at the house of a friend in the neighbourhood of Edinburgh, on the 9th December 1837, at the premature age of twenty-three. (See his Life by Mrs Johnstone, in the third edition of his poems.)

NICOLO, San, the chief town of the island of Tinos, in the Ægean Sea, and the see of a bishop, has a modern cathedral, and a population of 4000.

NICOLSON, William, Archbishop of Cashell, a learned antiquarian, was the son of a clergyman, and was born at Orton, in Cumberland, in 1655. Having entered Oxford in 1670, he was chosen a fellow of Queen's College in 1679, and was shortly afterwards presented to several livings. His favourite studies now began to be prosecuted with vigour. He produced *The English Historical Library* in 1696–99; and *The Scottish Historical Library* in 1702; a series of national antiquarian works, which he afterwards completed in 1724, by the publication of *The Irish Historical Library*. His increasing fame was attended by high ecclesiastical preferment. He was promoted to the bishopric of Carlisle in 1702; was translated to the see of Londonderry in 1718; and had the archbishopric of Cashell conferred upon him in 1726. His death took place a few days after his elevation to this last dignity.

Nicomachus ‖ Nicomedes.

NICOMACHUS, a distinguished Greek artist, the son of the painter Aristodemus, was a native of Thebes, and flourished in the latter half of the fourth century B.C. He rose to be unrivalled both for the celerity and completeness of his execution. If we may believe Plutarch, he closely resembled Homer in the spontaneous, and, at the same time, graceful and vigorous play of his genius; and, according to Cicero, his pictures attained the very pitch of perfection. His success as a teacher was also great. Among his pupils he numbered several who were afterwards famous painters, such as his brother Aristides, his son Aristocles, Philoxenes of Eretria, and Corybas. Yet Vitruvius enumerates him among those artists who were prevented by fortune from rising to their proper place in the public estimation. The following pictures of Nicomachus are mentioned by Pliny:—"The Rape of Proserpine," "Victory riding in a four-horsed Chariot," "Apollo and Diana," "Cybele," "Female Bacchanals," and "Scylla." He was engaged in a magnificent picture of the "Tyndaridæ," when he died.

NICOMEDES I., the earliest of the Bithynian kings who bore that name, succeeded his father Zipoetes in 278 B.C. He inaugurated his reign by the assassination of two of his brothers. This act of jealous cruelty rendered him unpopular. An insurrection, headed by his remaining brother Zipoetes, broke out and established itself in the maritime provinces. Before tranquillity could be restored, he was forced in 277 B.C. to employ the assistance of a horde of Gauls who were then besieging Byzantium, and thus to give that race for the first time a footing in Asia Minor. The rest of the reign of Nicomedes seems to have been spent in peaceful enterprises. In 264 B.C. he founded the great city of Nicomedia to be the capital of his kingdom, and to perpetuate his name. Other beneficial undertakings were progressing under his superintendence, when he died about 250 B.C.

Nicomedes II., surnamed Epiphanes, assassinated his father Prusias II., and seized upon the throne of Bithynia in 149 B.C. He had spent his youth at Rome as a hostage, had secured the favour of the senate, and was therefore inclined at first to trust for the prosperity of his kingdom to an alliance with the great republic. Not until about 102 B.C., did he attempt to act independently of his powerful allies. Joining himself to Mithridates, the great king of Pontus, he laid hold upon Paphlagonia; and though he pretended to relinquish his conquest at the command of Rome, he set one of his own sons upon the vacant Paphlagonian throne. The next encroachment of the crafty king was not so successful. By marrying Laodice, the widow of Ariarathes VI. of Cappadocia, and by taking her orphan sons under his protection, he thought to gain possession of that kingdom. But the strong hand of Mithridates was by that time upon the coveted crown; the Romans then interfered; and Nicomedes, besides being foiled in his project, was deprived of his former acquisition, the kingdom of Paphlagonia. He died shortly after this of disappointment, about 91 B.C.

Nicomedes III. was the son of the preceding, and succeeded his father about 91 B.C. His territories lay too

Nicomedia ‖ Nicosia.

near the seat of the grasping Mithridates to remain long in tranquillity. In a short time his brother Socrates, instigated by that intriguing foe, rose in rebellion and drove him from his kingdom. No sooner had the unfortunate king, by the intervention of the Roman senate, been reseated upon his throne in 90 B.C., than he was induced by the crafty counsels of Rome to embroil himself once more with Mithridates. The result was, that in the course of two years his forces were cut to pieces by the troops of Pontus on the banks of the Amnius; his kingdom was invaded; and he did not consider himself safe from his formidable enemy until he had fled as far as Italy. There he waited till the treaty concluded between Sylla and Mithridates in 84 B.C. restored him to his sceptre. The rest of his reign seems to have passed in comparative tranquillity. He died in 74 B.C., leaving no issue, and bequeathing his kingdom to the Romans.

NICOMEDIA. See ISMID.

NICOPOLIS (Turk. *Nikopol*, anc. *Nicopolis ad Istrum*), a town of European Turkey, capital of a pashalic in Bulgaria, stands on the right bank of the Danube, just below its confluence with the Aluta from the N., and the Osma from the S., 80 miles S.W. of Bukharest, and 280 N.W. of Constantinople. It consists of two parts; one of which, inhabited by Mohammedans, and protected by a fortress, stands on a cliff of limestone, several hundred feet high, rising from the river, and surrounded on the other three sides by a ravine. Though provided with heavy pieces of artillery, this castle, being commanded by the surrounding heights, is of very little importance as a defence. The Mussulman town is further defended by ramparts and batteries; and though generally ill built, it presents a fine appearance, with the many glittering minarets of its handsome mosques. On the slopes which rise beyond the ravine, stand groups of white houses, forming the other part of the town, and occupied by Bulgarians, Wallachians, and Jews. The surrounding country is very beautiful, and much of it is laid out in gardens. Owing to its convenient situation on the Danube, Nicopolis is a place of some commercial activity. It was originally founded by Trajan, of whose fortifications some remains still exist; and it is remarkable as the place where the Sultan Bayezid I. defeated Sigismund, King of Hungary, in 1396. It has since that time been repeatedly injured by the Russians. Pop. about 10,000.

NICOPOLIS, "The City of Victory," a town of ancient Greece, stood on the promontory of Epirus, on the low isthmus which separates the Ionian Sea from the Ambracius Sinus (*Gulf of Arta*). It was erected by Augustus in 31 B.C. to perpetuate the fame of the victory which he had gained at the neighbouring headland of Actium. Special care was taken to render it worthy of its imperial founder. A large population was drawn within its walls from the adjacent cities; it was admitted into the Amphictyonic Council; the privileges of a Roman colony were conferred upon it; and it became the scene of a quinquennial festival, called *Actia*, in honour of the above-mentioned battle. Under the successors of Augustus, Nicopolis continued to be the capital of Epirus. It was, however, gradually sinking into decay; and during the dark ages its dilapidated buildings were finally abandoned. About three miles north of the modern town of Prevesa, a line of ruins, stretching across the isthmus, and containing the remains of a larger and a smaller theatre, a palace, a stadium, and an aqueduct, still indicates the site of the ancient city of Nicopolis.

NICOSIA, a town of Sicily, in the province of Catania, occupies two hills near the rivers Salato and Capizzi, 35 miles W.N.W. of Catania. It has several churches and convents. Few or no manufactures are carried on here; but the inhabitants gain their livelihood by agriculture, and by trading in its produce and in cattle. In the vicinity alum, iron-pyrites, and rock-salt are found; and there are some bituminous and sulphureous springs. Pop. about 13,000.

Nicosia ‖ Niebuhr.

NICOSIA, or *Lefkosia*, the capital of Cyprus, stands near the centre of the island, on the right bank of the Pedia, in a plain inclosed by mountains. Though somewhat decayed from its former splendour, it still has a fine appearance when viewed from a distance; but the streets are narrow and dirty, lined by houses of which many are in a ruinous condition. It is surrounded by walls and bastions, which have a circuit of about 3 miles; but before these were erected by the Venetians, the town was of much greater extent. A handsome Gothic edifice, formerly the church of St Sophia, is now converted into a mosque, and many of its monuments have been injured by the hands of the Turks. Besides the churches, convents, and mosques, Nicosia has an ancient palace over the entrance of which the lion of Venice still stands; a handsome bazaar; and a khan or inn for the accommodation of travellers. Carpets, cotton stuffs, and leather, are manufactured here; and the principal articles of commerce consist of wine and raw cotton. Nicosia is the seat of a Greek archbishop, and of the Turkish governor of Cyprus. It was formerly the residence of the Cyprian kings of the Lusignan dynasty; and in 1570 was stormed by the Turks, who on that occasion put to the sword about 20,000 of the inhabitants. Pop. about 16,000.

NIEBUHR, BARTHOLD GEORGE, the illustrious historian of ancient Rome, was born at Copenhagen the 27th August 1776. He was son of the oriental traveller, Carsten Niebuhr. His family for many generations had been settled in Hadel, the north-western province of Hanover, where they occupied a small patrimonial estate. The elder Niebuhr had been employed by the Danish government on an exploring expedition in Arabia, in the year 1760, in which he exhibited remarkable abilities and energy. On his return, after suffering great hardships, he received an appointment in Copenhagen, married, and had two children,—a daughter named Christiana, and a son, Barthold George, a few years her junior. The mother was also a German by birth; so that Barthold, though born in Denmark, was himself German on both sides, and learnt the German as well as the Danish language in his nursery. When he was two years old his father removed to Meldorf, the capital of South Denmark, a district of Holstein, lying on the shore of the German Ocean, between the mouths of the Elbe and Eyder, which, though subject to Denmark, was occupied by a population claiming closer connection by origin and language with its German than its Danish neighbours. The inhabitants of this border-land had secured in the middle ages a certain political independence, of which they still retained the traces in their habits, their feelings, and their municipal institutions. From these institutions, in which the distinction of classes was strongly marked, Niebuhr drew many illustrations of his theory regarding the relations between the patricians and plebeians of ancient Rome.

The bent of Niebuhr's genius, and his habits of mind, may be traced more clearly than in most cases to the circumstances of his early years. From his father he derived his interest in languages, in geography, and in the manners and institutions of different nations, together with unwearied diligence and great earnestness of character. To his mother he owed apparently his moral and physical susceptibility; he was easily affected by change of climate and temperature, and liable to fits of peevishness and irritability; while at the same time he was endowed with great warmth of heart, and gained the devoted affection of his friends and family. From his father's employment as a fiscal agent in Denmark he acquired his turn for the subject of finance. Accustomed from his infancy to the marshes and moors of his

Niebuhr. province, it was not till late in life that he acquired a taste for picturesque scenery; to the last the fens of Holland and the plains of the Campagna had more interest for him than the romantic glories of the Alps and Apennines. Meldorf seems to have afforded him no companion of his own age, and but little society among his elders, which could assist in expanding his intellect; but Boje, the prefect of the district, an intimate friend of his father's, was a man of cultivated mind and literary taste; and young Niebuhr delighted in listening to their conversation, and, as he grew up, in devouring the contents of their libraries. Marvellous stories are told of the quickness of his observation, and his powers of memory. His first political interest was excited by the war between Russia and Turkey in 1787, the course of which he followed, or, if his father may be believed, anticipated, with the map before him; and the information he displayed in matters of history, geography, and statistics, was from the first extraordinary. In 1790, his thirteenth year, he was placed at the gymnasium of Meldorf; in 1792 he was removed to a commercial school at Hamburg, and in 1794 was admitted into the university of Kiel. The system of education at a small German university such as Kiel, was very similar to that, little noticed and soon to be forgotten, pursued in our East India College at Haileybury. The students, about 100 in number, lived in habits of easy intercourse, and often of affectionate friendship, with the professors and authorities, frequenting their little parties, and associating with their wives and daughters. The course of study, ranging over two years, was wide, but necessarily superficial, exercising the memory more than the understanding; the students attending, with considerable latitude of choice, the lectures of teachers in the learned languages, in German and Danish history, in jurisprudence, logic, metaphysics, natural philosophy, chemistry, "æsthetics," and philology, and probably others, delivered orally and taken down in writing; great stores of which manuscripts, more or less methodically arranged, they carried away with them to form the basis of future works or lectures of their own. On all these subjects Niebuhr gained crude masses of information which none but a mind of extraordinary activity, such as his own, could have digested. But a more important acquisition than all this learning, for the future development of his character, was the friendship of Madame Hensler, the widowed daughter of one of the professors, a woman of remarkable sense and intelligence, towards whom, being six years her junior, he continued through life to entertain the most respectful regard, with whom he corresponded, without reserve, on all his thoughts and feelings, and whose younger sister he afterwards married. Here he also formed many valuable intimacies; *e.g.*, with the two Counts Stolberg, with Count Adam Moltke, with Voss, Jacobi, Reventlow, and Schlosser.

At Easter 1796 Niebuhr left Kiel. The reputation of his abilities had become known to Count Schimmelmann, the Danish minister of finance, who offered him the place of private secretary. The elder Niebuhr, it seems, had looked forward to his son following his own steps as a geographer and explorer; but he felt that the delicacy of his health was an obstacle to the realization of this plan, and he now advised him to accept this opening to official life at home. Niebuhr accordingly went to Copenhagen, and entered his new patron's service; but in August the same year he was appointed secretary to the royal library by the prime minister Bernstorff, the duties of which post he combined, at least for a time, with those of the other. Almost at the same time he received the offer of some literary post in France; and again Schimmelmann proposed to him the situation of consul-general at Paris. Both these offers he declined. "How could I bear," he said, "to live so far from all who are dear to me, among a nation to whom in general I have an aversion?" Such was the variety of openings, not lucrative perhaps, but involving some responsibility, which presented themselves to a young German of twenty years of age, known for his abilities only in the small circle of one of the least conspicuous of German universities. Niebuhr.

In August 1797 Niebuhr went to see his friends in Holstein. On this occasion the regard he had long entertained for Amelia Behrens, the younger sister of Madame Hensler, determined him to make her the offer of his hand; and the young couple, Niebuhr being at this time twenty-one, and the lady three years older, became solemnly betrothed. He returned to his duties at Copenhagen; but his views now pointed to a professorship at Kiel, which might enable him to marry, and devote his life to literary labours. Before, however, entering deliberately on the career to which he had destined himself, Niebuhr was anxious for the improvement to be derived from foreign travel, and particularly for an opportunity of making himself acquainted with England, a country to which his father was much attached, and in which he had himself felt especial interest from a child. In June 1798 he sailed from Cuxhaven, landed at Yarmouth, and went direct to London, where he resided till October, and then fixed himself for six months at Edinburgh. Here he attended the university for one session, and after travelling through parts of Scotland and England, returned home in November 1799. His letters from this country show with what active interest he studied the character and customs of the English; but it is to be regretted that the acquaintance he formed here was confined to a few families and individuals within a narrow circle; and the habit of hasty generalization, to which he was through life addicted, was never more conspicuous than in the conclusions he drew from his limited experience regarding the whole subject of English life and manners.

In the spring of 1800, Niebuhr having obtained two small appointments from the government at Copenhagen, took up his residence there, and married his betrothed. It is from this time that his thoughts and reading began to be directed particularly towards classical antiquity, gradually centring in the history of ancient Rome. Six years passed in intense study and moderate employment, until, in 1806, his name, not only as a scholar, but as a man of business and knowledge of commerce and finance, rising higher and higher, he received an invitation to transfer himself to the service of the Prussian government. In accepting this offer, after mature deliberation, he acknowledges himself to have been influenced in some degree by pique at an anticipated slight in his official career in Denmark. His temper was undoubtedly irritable, and his extraordinary quickness of apprehension was combined apparently with some restlessness; but the charges sometimes made against him, of ingratitude to his first patrons, and insensibility to the claims of his country, are wholly unreasonable. Schimmelmann and Bernstorff seem to have given their full consent and approval to his proposed migration; and Niebuhr, as we have seen, was himself a German, not a Dane, by origin. At that moment, in the attitude of resistance to France assumed generally by the nations of Eastern Europe, a feeling of common nationality pervaded all the people, at least of Teutonic birth and language. At a later period, indeed, when the independence of the whole of Germany seemed hopelessly lost, Niebuhr could contemplate without hesitation the prospect of seeking a retreat for his literary labours in Russia.

The change of life, however, which he now made was, at its commencement, far from auspicious. He had enrolled himself a citizen of Prussia at a moment when the very existence of the Prussian state was trembling in the balance. He arrived at Berlin, October 5, 1806, only nine days before the fatal battle of Jena, which, with the disas-

Niebuhr. ters which rapidly followed, obliged him quickly to quit the capital, and seek more and more distant retreats in the train of the flying government. He thus passed through Dantzic and Königsberg; and at last, about the beginning of 1807, found himself at Memel, the northern extremity of the kingdom. He had been placed in the department of finance, for which he was qualified by previous connection with the bank at Copenhagen. The minister who had discovered his merit, and secured his services for Prussia, was Von Stein, who seems to have had the highest confidence in his abilities as a financier. But the overthrow of Prussia in the war with France brought about a complete change of administration. Stein was replaced by Hardenberg; yet, though he lost a personal friend at the head of affairs, Niebuhr's talents seem to have been not less appreciated by the new minister. The financial department of the commissariat was intrusted to him, and he removed to the head-quarters of the government at Tilsit; till, on the utter overthrow of Prussian independence, he desired leave to retire to Copenhagen, and there await the result. He was prevailed upon to remain; and when Napoleon demanded the dismissal of Hardenberg, Niebuhr, in the wreck of the government, was appointed with four others as a provisional commission to carry on affairs till a new administration could be formed. The finances of the country were, of course, in utter confusion; immediate measures were required to provide for paying the interest of the public debt; and some fiscal reforms and arrangements, now set on foot by Niebuhr, were accepted afterwards by Stein, when he succeeded to the head of the government. Niebuhr was now appointed to negotiate a loan at Amsterdam, and thither he repaired with his wife in March 1808. There he remained for a year; but his negotiation was unsuccessful: he paid a visit to Ditmarsh in 1809, and returned to Berlin at the end of the year, where he was once more placed at the head of the department charged with the management of the national debt and the supervision of the banks.

In 1810 Niebuhr found his administrative views so much at variance with those of Hardenberg, who had once more replaced Stein, that he demanded his dismissal, and requested at the same time an appointment as professor at the new university then about to be opened at Berlin. In his conduct in this matter it seems impossible to acquit him of waywardness, and of weakly giving way to his habitual restlessness of disposition. Hardenberg was sincerely anxious to retain his services, willing to discuss and consider his views, and to come to an understanding with him; and Stein himself, the rival of Hardenberg, and Niebuhr's patron and personal friend, judged his conduct indefensible. In a private letter to Humboldt, Stein thus expresses himself,—"Niebuhr declares his dissentient opinion. M. von Hardenberg invites him to discuss the matter with him, and to send another plan: to this he vouchsafes no reply; but instead hands in a lengthy chain of arguments against Hardenberg's plan to the king, without bringing forward any other project; and now he wants to appear as a martyr to the truth. All this is nothing but a refined egotism," &c.[1] Niebuhr, it would seem, was beginning to pine again for the literary occupation to which he was always recurring in the midst of his official duties. After stating to Madame Hensler, in very general and vague terms, his grounds of dissatisfaction with the government measures, he adds,—"Besides this, I must confess, that my sorrow for the sacrifice of *my inward life* to this *miserable finance* often wakes up with renewed force." He allows himself to ramble on in a very unworthy strain of reflection. "A consciousness how dearly any perfection in this art must be purchased by a man who is fit for something better, is Niebuhr. probably the true reason why *so few honest men have ever made themselves masters of it.* . . . . . For a long time past I have been almost unable to refresh myself by study. . . . . This *estrangement from my true life* has now lasted nearly three years and a half." It was evidently high time, to speak in the mildest language, that the man of letters should return to the occupations from which he had been so long dissevered; and we may rejoice, as he did himself, when the king acceded to Hardenberg's recommendation, and gave him the post of historiographer. The minister, however, continued to consult him occasionally on financial matters; and Niebuhr, released from the responsibilities of office, was not unwilling to tender his counsel.

We may ascribe to the natural vanity of a young man, raised to important public offices by the disastrous circumstances of his country,—for the flower of the youth of Prussia was drained off into the army,—the overweening opinion Niebuhr seems to have entertained of his administrative abilities. But none of his admirers—and no man has received more indiscriminate admiration—have ever pointed to any special service he rendered to Prussia in the various situations he filled in the government; and there seems much reason to apprehend that, in relieving himself from his official duties, he yielded to an impracticable temper, ill suited to the conduct of public affairs. However this may be,—and his friends, it should be mentioned, averred that eventually even Stein acknowledged the correctness of his views on the question between him and his superior,—there can be no doubt that the change now made in his career was fortunate for his fame, for his comfort, and for the interests of literature. From this time Niebuhr experienced but little interruption in his devotion to letters, to classical antiquity, and specially to the history of Rome. When the Prussian government was in want of able civil administrators to direct or recruit the finances, it was obliged to seek out a clever youth from a neighbouring country, almost fresh from academic distinctions; but when it had to create a new university in its capital city, and furnish it with a body of professors fitted by their reputation and abilities to place it at once on a level with the oldest and most renowned seats of learning in Germany, it could command the services of a whole corps of men, each of them among the most illustrious in his own department of knowledge. Niebuhr, whose reputation was destined to eclipse them all, was less famous in 1811 in the republic of letters than Schleiermacher, Savigny, Heindorf, Buttmann, and others perhaps of the Berlin professors, among whom he was now to be admitted. In the prostration of Prussia at this period, while Stein at least, and a few others perhaps, were secretly preparing the country to re-assert her independence at the favourable moment, the men of letters seem to have made up their minds to forget their political degradation in their earnest devotion to intellectual speculation. The university of Berlin gave great impulse to thought among the educated men of the country; the professors above enumerated exercised, with many others, great influence on the intellect of the age, and impressed a character for boldness, freedom, and originality upon the literature of Northern Germany. In his capacity of historiographer, Niebuhr devoted himself specially from the first to the history of ancient Rome. In 1811–12 he delivered courses of lectures upon this favourite subject; and these, with the promptness and ardour of his impatient temperament, he worked up without delay into two volumes of a history, which he published before the close of the second of these years. The appearance of the original edition was unfortunately timed. The stirring political events

[1] Steins' *Leben*, ii. 507, quoted in *Niebuhr's Life and Letters*, i. 234.

Niebuhr. of 1813 cast it wholly into the shade. Even the author, in the ardour of his patriotism, was contented to forget it while he himself carried a musket on the exercising ground, and undertook at the same time the conduct of a political journal. With the return of peace and leisure for literature, the history was not found to command all the approbation or attention its author might have expected. Though at a later period, as has been already intimated, he changed his views on many essential points, he was far from acquiescing at the time in the objections urged against them, and continued loudly to proclaim the blindness and stupidity of all who refused to accede to them. It was fortunate, perhaps, that a long interval was now given him for reflection. He had scarcely resumed the quiet tenor of his lectures and studies, after the return of peace, when it was painfully interrupted by the increasing weakness, and finally by the death, of his amiable wife, whose health, always precarious, seems to have suffered much from the hardships of the migratory winter of 1806. Her parting injunctions to him were to continue his history "for her sake;" she had perceived, perhaps, that his task had become already irksome to him, and he wanted encouragement to pursue it. But her loss for the time completely broke his spirits, and he accepted, as a relief, the timely and considerate offer of the Prussian embassy at Rome,—a post which ordinarily was little more than honorary, but which, in the contemplated event of a concordat being arranged with the Pope, would require both tact and ability. Before setting out on this long and distant banishment, at which his sensitive nature was considerably dismayed, Niebuhr was fortunate in securing himself a second wife in the person of Margaret Hebrem, the niece of Amelia, a woman of excellent sense, though probably with less appreciation of his intellectual character than the first, and who, confident of the influence she should gradually win over his affections, was content to stand avowedly second for a time in his imagination.

In July 1816 the newly-married couple quitted Germany. They were accompanied by Brandis, who has since attained a distinguished name in literature, as secretary to the legation. They passed through Wurzburg and Munich, where Niebuhr did not omit to examine the MSS. in the libraries; Innsbruck, where he inquired with intense interest into the circumstances of the recent patriotic struggle of the Tyrolese; and Verona, where he made his discovery of the Institutes of Gaius. This discovery was notified by Niebuhr in a letter to Savigny from Venice, but he at first supposed the fragment to be a portion of Ulpian. He copied on the spot a single leaf, and sent it by way of specimen to his friend at Berlin, where measures were promptly taken for the recovery and publication of the lost treasure. After visiting Venice, Bologna, and Florence, he reached Rome on the 7th October 1816. At the period of his arrival there he seems to have been depressed in spirits and suffering in health; he saw Italy also for the first time under the pressure of famine; and, among other personal inconveniences, the vessel in which his books were sent to Leghorn was wrecked at Calais, and he remained for several months uncertain of their fate. He complained of the character of the people; he was dissatisfied with, perhaps disappointed at, the meagre remains of antiquity which were alone apparent—at least on a first view—upon the site of the greatest of ancient cities, as well as in the country around; and he was harassed by the difficulty of studying at a place where he could only read in the public libraries on certain days, and for some limited hours. Under these circumstances, peculiarly untoward to a man of his temperament, he seems to have been long unable to work upon the History to which he had hoped to devote himself with more zeal than ever; and though he was never idle, and constantly making some discoveries among the MSS. of the Vatican, he did not for some time recover the even tenor Niebuhr. of his literary habits. Gradually, however, the vexations of his position wore off; he was able to look with more indulgence on the character of the people; he found more to admire and attract him in the scenes around him; the respect in which he was personally held enabled him to relieve himself from the frivolities of the society among which his position might have thrown him; he regarded with genial sympathy the enthusiasm of a clique of young German artists, especially the painter Cornelius, who, in their turn, revered him as a patron and director; and, finally, the birth of a son, in April 1817, came opportunely to brace all his energies, and fill him with pleasant and hopeful views of life. To the child he gave the Roman name of Marcus; and began from the first month of its existence to lay out his plans for its future education and career. He continued all this time in constant correspondence with his literary friends at Berlin, especially with Savigny and Nicolovius; but his letters to Madame Hensler still present, as before, the fullest picture of his life, his thoughts, and his interests. He occupied himself with his usual assiduity, but in desultory studies, tending, however, for the most part, in the direction of Roman history, the reading of the Latin scholiasts, the publication of various fragments he discovered of Livy and Cicero, and the investigation of the history of the successors of Alexander, as a preparation for the period when the Romans first came in contact with the Greeks and Orientals. During the greater part of his residence in Rome he occupied lodgings in an old palace built on a lofty story of the ancient theatre of Marcellus, which lies between the Capitoline and the Tiber.

The negotiations with the papal government, to carry on which Niebuhr was ostensibly sent to Rome, were not brought to an issue till 1821, when he had been at his post more than four years. The favourable termination of the affair followed quickly upon a visit paid to Rome by Hardenberg in person, and the minister's friends claimed for him the merit of settling it. The friends of Niebuhr, on the other hand, maintained that all the preliminaries had been arranged by him, and that the successful issue itself, though Niebuhr himself allowed all the credit of it to fall to his superior, was owing to his zeal and tact. There can be no doubt that Niebuhr had made himself personally respected both by Pius VII. and his minister Cardinal Consalvi; but it appears that he had to wait nearly four years for his instructions from the court of Berlin, and in the negotiations themselves he could have borne little part. At all events it would seem, from the serious quarrels which ensued fifteen years later between the popish Archbishop of Cologne and the Prussian government, that the concordat, whether it were the work of Hardenberg or of Niebuhr, failed to make a practical settlement of the questions it dealt with.

Brandis, the secretary of legation, had removed from Rome before this time. He was succeeded by Bunsen, who became one of the most devoted of Niebuhr's friends and admirers. In 1821 Niebuhr was engaged in sketching the plan of the great work on Roman topography which Bunsen, Platner, and other coadjutors, have since given to the world,—a work ill arranged and unequal in the execution of its parts, but deserving, on the whole, to be considered one of the most important and valuable of modern additions to our knowledge of Roman antiquity. Some of the chapters, particularly that which gives a general history of the site of the city,—the most vivid and interesting of the whole,—were contributed to the work by Niebuhr.

In 1822 Niebuhr had been six years absent from home. The chief object of his mission had been effected, and notwithstanding the increasing estimation in which he was held, and his consequently increased means of usefulness, evinced on some public occasions, he became anxious to

Niebuhr. return to Germany. His family now consisted of one son and three daughters, and he was dismayed at the idea of bringing up children amidst a society for which generally he had so little respect. Having obtained, in the first instance, temporary leave of absence, he allowed himself, apparently for the first time,—such was the insecurity of the country even round Frascati and Tivoli,—to leave the immediate neighbourhood of Rome, and paid a visit to Naples in the spring of 1823. Returning from thence at the end of five weeks, he took his farewell of Rome, and commenced his journey northward in May. At St Gall he passed some weeks, to recruit his health and to examine the MSS. in the library there,—a labour which was repaid by the discovery of the poem of Merobandes, which he prepared for publication during his stay. From St Gall he went to Heidelberg, and then on a visit to Brandis at Bonn, where he proposed to take up his residence until it should be finally decided whether or not he should return to his post at Rome.

At Rome, Niebuhr resumed his history in earnest. Some new light had dawned upon him, and cleared up difficulties that had long, perhaps unacknowledged to himself, thwarted his efforts to make any substantial advance. But while still engaged on his third volume he recurred to the correction, and eventually to the re-casting of the two former, and these occupations were again interrupted by a visit to Berlin. Here he obtained a final release from his duties as ambassador, and was gratified with a pension. He was expected, however, to remain for a time in the capital, and give his aid to a financial commission. In the course of 1824, however, he was allowed to return to Bonn, and to devote himself to studies, directed henceforth, rather than interrupted, by the congenial duty of delivering lectures in the university on ancient history. His first course (1824) was on the history of Greece after the battle of Chæronea: this was followed by others on Roman antiquities, in the winter of 1825, repeated in 1827; on ancient history generally, 1826; ancient ethnography and geography in the winter of 1827; the history of Rome under the empire, in 1828 and 1829; and a second course on earlier Roman history, in the summer of 1830.

The appreciation of Niebuhr's services to literature seems to have grown rapidly at this period, and this evidently inspired him with more genuine confidence in himself than, notwithstanding a sanguine, indeed we must say a boastful, habit of talking, he had hitherto really felt. In October 1825 he began to work again regularly on his History, and he commenced a thorough revision of the first volumes, without a pang of regret for the past or misgiving for the future, with the full assurance that the book was about "to gain immensely in value," and "its principles to be fixed immoveably for all ages." "I do not hesitate to say," he writes in April 1827, "that the discovery of no ancient historian could have taught the world so much as my work; and that all that may hereafter come to light from ancient and uncorrupted sources will only tend to confirm or develop the principles I have advanced." When the two volumes appeared in their new form, they were at once received with acclamations by the learned, and Niebuhr undoubtedly had the happiness of feeling that he had given a new impulse to historical study, and created, in fact, an era in literature. Among the compliments he received, none seems to have been more gratifying to him than the zeal and ability with which his work was translated by Messrs Hare and Thirlwall, and the favour with which, under their auspices, it was regarded at the university of Cambridge.

Besides working at his History (which he carried on through a third volume), and the daily occupation of the lecture-room, Niebuhr found time to undertake the superintendence of a great work, no less than the publication of the *Corpus Scriptorum Byzantinorum*, to which he himself contributed an edition of Agathias. His name attracted a number of able assistants, and he received abundance of important subsidies from foreign countries, as well as from Germany, in the shape of collections, emendations, &c. Of this work he speaks with his usual ardour: "Is it not a great thing that a publisher and a philologist should be able to accomplish in six years from hence at the furthest, a work that was but partially carried out in sixty years, under the auspices and with the munificent aid of Louis XIV.?" But his labours now were as regular and methodical as they were incessant. His residence at Bonn continued with hardly a day's interruption, excepting one journey to Holstein; his mode of life was simple, his hours of study and relaxation systematically allotted, and though always actively alive to the politics of the day, and a regular frequenter of the public news-room, he did not suffer his attention to be diverted to other literary occupations than those above mentioned. He no longer indulged in visions of great works to be carried on simultaneously with his History, nor even to succeed it. He began even to limit his views with regard to the great work of his life, and prescribed the triumph of Octavius as the termination of its career. Yet he was more cheerful at this than at any other period of his life, and seems to have hoped to attain his seventy years, like the generality of people, as he says, about him. He had visions also of a future visit to Rome, "twelve years hence." But all these visions or anticipations were suddenly cut off. In the winter of 1830 he had the misfortune to suffer the loss of his house and some of his books and MSS. by fire. He returned to his work with more elasticity of spirit than might have been expected at his age; nevertheless he was considerably shaken by the anxiety and mortification it occasioned him. The French revolution of July 1830 was a still severer blow. He had long regarded the progress of republican principles with a morbid horror, and his mind was now filled with the worst forebodings. He became more assiduous than ever in his study of public events, and in his visits to the news-room. At last, on the evening of Christmas-day 1830, he caught a chill in walking home from the casino, where he had been more than usually excited and heated in perusing the account of the trial of Charles X.'s ministers. He took to his bed, but inflammation of the lungs set in, and in the course of a week his illness reached a fatal termination. He died on the 2d January 1831; and his wife, who had sickened at his bedside, died also on the 11th. They were buried in the same grave, over which the present King of Prussia, formerly his pupil at Berlin, erected a neat and appropriate monument. Upon it a Roman Caius is represented as taking his Caia by the hand, and the lineaments of the two figures portray, with a certain air of Roman formality and sternness, the features of Barthold George Niebuhr and Margaret Hensler. In the summer of 1831 this monument was not yet in existence; but the eyes of the writer of this notice were attracted to a simpler memorial of the great historian at Bonn, in the brass plate on which his name was inscribed still affixed to the door of the house which was his no longer.

The reputation of Niebuhr as a philologer and historian had reached, as we have seen, a distinguished eminence at the time of his decease, and it still continued to rise. He was admitted, both in Germany and in this country, as a standard authority on the points of classical antiquity to which he had devoted himself, and the revolution he had aimed at effecting in the principles of Roman history were accepted, almost without dispute, as accomplished and ratified. According to the testimony of his admirer the Chevalier Bunsen, he was even more fully appreciated in England than in his own country; and the fact of 7000 copies of the English translation of his History (vols. i. and ii.) having been purchased within eight or ten years from the publication, is adduced in proof of our superior discernment. But

Niebuhr. even in Germany, as Niebuhr himself remarked, with reference to the sale of his *Byzantine Corpus*, a class of wealthy collectors had arisen, the number of which furnished no measure of the number of readers; and any man acquainted with English scholarship knows well that, notwithstanding a certain amount of superficial reading or handling of Niebuhr's volumes, there were but few among us who really made a study of them, or rendered themselves competent to express a reasonable judgment upon them. Still, the great principles of his work, his reputed discoveries, and more particularly the spirit in which they were conducted, sank deeply into the academic mind of England; and his genius, especially after it received the enthusiastic adoration of Arnold, was admitted as almost beyond cavil, or even qualification. In Germany the results of his investigations were more strictly questioned from an early period, and more severely criticised. The time was coming when a great re-action was to set in with regard to Niebuhr's estimation in this country also. There can be little doubt that the publication of his Lectures, and still more of his correspondence (*Lebensnachrichten*, &c., abridged and translated into English, 1852) has tended very sensibly to diminish it. The Lectures, it must be allowed, have been published at a great disadvantage, having been only taken down from his oral delivery in the lecture-room, and bearing evident marks, not only of the occasional haste and incorrectness of all lectures delivered *vive voce*, as these were, without even the assistance of notes, but of inexperienced and unskilful abridgments, and often of actual misconception. Of these Lectures three series have been given to the world by Dr Leonhard Schmitz, himself a hearer of them: they embrace a course on Ancient History generally, which must be pronounced extremely meagre and colourless; and another on Ancient Ethnology and Geography, about one-half of which is devoted specially to Italy and Rome, undoubtedly far more interesting, though abounding, to what must be called a morbid extent, in crude theories and groundless assertions. A third course, that on Roman History, extending as far as the reign of Constantine, gives a connected view of the spirit in which Niebuhr would have treated the later portions of the work before him; it cannot be said, however, that it evinces any of the novelty or originality which so strongly characterize his discussions on the earlier period, nor is it drawn out sufficiently in detail to enable us to judge of his powers of narration and description. On the whole, it must be said that these Lectures have been received with great disappointment by the English reader, and have given a shock to the feeling of unbounded devotion with which the author was previously regarded.

The publication of the *Lebensnachrichten* is perhaps still more to be regretted than that of the lectures. The correspondence of Niebuhr exhibits, no doubt, in glowing colours, his earnestness of character, his strict integrity, his generous sympathy with everything noble, and detestation of all meanness and injustice. Yet all this was patent to a reader of ordinary insight on the face of his published History, and required no further illustration from his life and letters; while the evidence we receive from it of his amiableness as a son, a husband, a parent, and a friend, is in some measure balanced by certain indications of peevishness, changeableness, and other infirmities of temper, which are calculated to provoke and mortify those who were most disposed to admire him. But it is with Niebuhr's literary character that we are most concerned. The correspondence, and various essays and fragments of essays on literary and political subjects, contained in the *Kleine Schriften* betray infirmities of judgment which are quite surprising.[1] His views, for instance, on the dates of Petronius and Quintus Curtius, are now generally regarded as founded on very inadequate bases. His theory that the municipal institutions of Italian towns in the middle ages were derived, not from the northern conquerors, but from the Romans, has been rejected by modern inquirers. He was especially proud of his acquaintance with the institutions and politics of England; yet he was wont to illustrate the claims of the Italian allies on the Roman republic by comparing them with the demand of the Irish Catholics for the so-called emancipation, forgetting that from 1793 the Catholics had acquired the franchise, the point for which the Italians contended, and that their later cry was for admission to Parliament, to which the claims of the Italians presented no analogy whatever. His want of practical good sense is shown characteristically in the notion he elsewhere promulgates, that it would have been best for the world that Spain should have retained her American colonies, opening the trade with them to foreign nations through Cadiz as an emporium, evidently with a retrospect to the days of ancient or mediæval commerce. All these views, and many others equally frivolous, are advanced with a dogmatism which is painful in a man of real genius, as in any other it would be ridiculous. Further, we have clearly seen how much he prided himself on his insight into the principles of finance: yet we have observed how, on the first occasion when an opportunity really offered for bringing this insight to a practical test, he broke down completely, and, in fact, fled from his post. Gibbon gives three reasons for the decline of the Roman empire: a distinguished English writer of the present day has rejected them all, and laid it wholly on the restriction of the currency and the want of bank-notes. This is a question which it requires not book-learning but actual knowledge of affairs to solve; and of all others it is the question which we had a right to look to Niebuhr, with his official training, to elucidate. Yet, strange to say, there is not a single passage in his History, his Lectures, his Essays, or his Correspondence, which shows that he had ever considered the financial and monetary system of the Romans at all.

Niebuhr.

Grave complaints have been made against Niebuhr by the Liberals of modern days, for his alleged desertion of the cause of freedom. A fair consideration of his various writings fully rebuts this ill-natured accusation. That there are indications in the course of his life of some vacillation and indistinctness in his views, is no more than may be said with equal truth of almost all thoughtful men,—men of speculation rather than of action,—whose lot has been cast in periods of change and amidst the trial of political principles. Niebuhr's political creed is ably and satisfactorily drawn up in a communication from the Chevalier Bunsen to the translator of his Correspondence; though we must here again remark the unpractical character which appears on the face of his scheme for developing the parliamentary system of Prussia. Deeply impressed as he was with the hollowness of the election system in modern European constitutions, on a mixed but uniform basis of property and numbers, he would have filled his deliberative assemblies by appointment from town-councils and corporations,—a notion which he probably derived from the conventions of the Roman provinces under the empire.

There is yet another subject on which it is still more painful to speak. The character of Niebuhr's mind is remarkably exemplified by his manner of dealing with religious subjects. His feelings on this point were from the first deep and strong. They survived the rejection which, after the many in-

[1] The third volume of the English "Life and Correspondence" contains a selection from the *Kleine Schriften* or "Lesser Writings," as well as from the *Nach-gelassene* or "Posthumous."

Niebuhr. stances of precipitate judgment on his part already alleged, we may call hasty as well as ill-considered, of the greater part of the positive belief of the Christian world. It was on the birth of his son that the sense of the indeterminateness of his own creed,—of the chasm between his feelings and his opinions,—became suddenly intolerable to him; and he determined, and with his curious simplicity of character bluntly declared his determination, that the child "should believe in the letter of the Old and New Testaments." ... "I shall nurture in him," he adds, "from his infancy a firm faith in all *I have lost or feel uncertain about.*" After such an avowal, it is impossible not to feel great distrust in Niebuhr's speculations on other subjects, and apprehension lest, in perfect good faith and sincerity, he should fatally mislead us for the satisfaction of a theory or a sentiment.

Let us now turn, in conclusion, to the History, the great work by which our author will continue hereafter to be known, and by which it were much to be wished that he could be known only. Niebuhr, it must be clearly understood, comes before us much less as a destroyer of the early Roman history than as a restorer. Among enlightened students of antiquity the incredibility of the narratives of Livy and Dionysius was already admitted, though the main features of these accounts still retain their hold upon them, from the apparent impossibility of constructing a substantial edifice from the fragments of truth, and a natural reluctance to let the ground lie unoccupied. It was not then the destructive, but the reconstructive part of Niebuhr's History which gave it its peculiar character, and kindled so warmly the imagination of his most intelligent readers. Arnold, above all men, was grateful to his master for restoring to him the possibility of a belief in the Origines of Roman history. But a sterner, perhaps a colder criticism, has dispelled these last shadowy visions. Among other writers,—for Niebuhr's theories have been a fruitful field of controversy, particularly in his own country, ever since their publication,—Schwegler in Germany, and Sir G. Cornewall Lewis among ourselves, have shown, it should seem, the actual baselessness of some of the chief of his reputed discoveries.

The most important of these discoveries, or theories, as we must be content to call them, is undoubtedly that which was received with unhesitating conviction, and rendered so popular, in this country at least, by Mr (now Lord) Macaulay and Dr Arnold, as to have been for many years accepted by all our scholars and students as an ascertained fact; namely, the presumed derivation of the early history of Rome from ancient national ballads. Schwegler, a very competent and trustworthy authority on the present state of the controversy, declares that in Germany this theory has been now generally abandoned. Sir G. Cornewall Lewis has recently analysed and discussed it in a masterly manner; and it may be presumed that it will henceforth retain little favour with those among us who have read the *Essay on the Credibility of the Early Roman History*. The positive evidence on which it pretends to rest is shown to be utterly inconclusive. The passages cited from Cato, Varro, Ennius, Cicero, Horace, and Valerius Maximus, are all absolutely irrelevant. The assumption, that fragments of these supposed ballads may be traced in the narrative of Livy, is wholly gratuitous; the assertion that some of his prose is actually verse, and may be read into Saturnian metre is only an amusing fancy; the attempt to produce any analogous instance of history preserved in national poetry is entirely futile. Such is the conclusion to which, whatever his own early prepossessions may have been, a candid inquirer must be brought by a fair examination of the subject, as it is now presented to him.

But interesting and seductive as this theory proved to the first students of Niebuhr's History, it was still less attractive perhaps than his interpretation of the relations of the patricians and plebeians, as representing respectively a dominant and a subject race, coalescing gradually into a single political body. This idea, which Niebuhr has developed with peculiar force, and illustrated by minute and multifarious learning, was not wholly new; nor did he stand alone in his own generation in marking the importance of regarding such national relations. The theory that most historic polities have sprung from the subjection of race to race, and that their career is generally to be explained only by constant reference to this circumstance, has been prolific of very serious consequences in modern times. It is not too much to say, that the revolutionary movements which pervaded so large a portion of western Europe in 1848 were directed in no slight degree by pedantic notions of the influence of race and nationality. Niebuhr in Germany, and Thierry in France, gave birth simultaneously to a school of history in which this theory played a conspicuous part. The French writer acknowledged that he derived the first germ of the idea which he developed in his brilliant romance of the *Conquest of England*, from a few pages in an early chapter of Scott's novel of *Ivanhoe*. There can be little doubt that Niebuhr was right at bottom in conceiving that the institutions of ancient Rome were really moulded, in a great measure, by the mutual relations of different races, with different habits, feelings, and languages, and also with a different political status, yet combining in one polity; but it cannot be allowed that he was always successful in tracing these differences, nor, indeed, that it is now possible to disentangle the hopeless intricacies of the Roman constitution. Thus, for instance, the distinction he alleged, that *populus* properly means the patricians, as opposed to *plebs*, the plebeians; and his bold assertion that Livy was incorrect in using *populus* for the nation in general,—a theory which was once eagerly embraced as the key to much of the early history,—must now be regarded with distrust. His explanation of the real object of the Agrarian laws, which is founded also on his fundamental distinction between the patricians and plebeians,—the burghers, as he delights to call them with reference to certain mediæval analogies, and the commons,—has been also severely contested; but this view, so clear, so interesting, and so apparently satisfactory, may be considered as tolerably well established at the present day. Niebuhr.

It will appear, from these remarks, that even in his History, on which the fame of our author pre-eminently rests, he is convicted by modern inquirers of error in some of his fundamental positions. His work can never again be accepted, with the faith and admiration of Arnold, as the basis of a history of Rome. The notion of reconstructing Roman history, of shelling off the husk of the ancient narrative, and bringing to light a new body of facts, of which Livy and Dionysius were wholly ignorant, will probably be discarded from henceforth; while some writers will always be found to cling pertinaciously to the legends of antiquity, others will plunge more and more deeply into scepticism; and we may expect perhaps rather to see the accounts of the later republic and the empire pulled to pieces, than those of the kings and the decemvirate restored.

It is not without pain that the students of Niebuhr—those who have been mainly led by him to look beneath the surface of history, and examine the principles of human affairs—can consent to abandon so large a part of his conclusions, and modify so far their veneration for their master. But Niebuhr must follow the fate of the great inventors before him. Bossuet was the first to snatch at the clue of a Divine Providence through the history of man; and he created a school of historians which will continue always to have its disciples, however much the specific views and conclusions of their founder may be modified or rejected.

Niebuhr. Voltaire and Montesquieu sought the springs of history in the manners and institutions of society; and they, too, have generated a school of philosophic inquiry which has long survived the reputed discoveries of its originators. Niebuhr himself indeed may be regarded as a pupil of this school, though in the depth of his investigations, the sagacity of his combinations, and the boldness of his inferences, he stands far before it, and deserves himself the reputation of an originator and a founder. It is due to him to lay before the reader, in a few words taken from the introduction to his *Lectures on Ancient Ethnography, &c.*, the view he deliberately took of the province of the historian:—

"All history resolves itself into a knowledge of the circumstances in the midst of which events occur, and of the events themselves. In an abstract point of view, the two are conveniently kept apart, although, concretely, they can never appear separated. A history which does not enter into the development of circumstances at all, and altogether presupposes them to be barren, is scarcely conceivable, unless indeed it were written for contemporaries alone. Nevertheless, the one side or the other predominates according to the predilection of the individual historian. Livy gives scarcely anything but the narration of events; earlier historians are fond of occupying themselves with the description of circumstances; and the more ancient the historian the more striking is the peculiarity. Thucydides, the greatest of all historians, whenever he has an opportunity, as in his description of nations, dwells upon the representation of circumstances. In the earliest times, therefore, ethnography and chorography were always the principal objects of attention; while, subsequently, this tendency decreased more and more, and the narration of events alone was attended to. The two, however, ought not to be separated; for, without a knowledge of the circumstances in the midst of which events take place, the study of history is altogether useless. The mere knowledge of a country, however, is not sufficient. The peculiarities of its inhabitants, products, and the like, must be well known to the student; and without this, history has no life," &c. Animated with this view of what was required in a true expounder of the events and facts of past times, Niebuhr tried to surround himself, as it were, with glowing pictures of the whole life of the people of whom he wrote. His immense erudition, his extraordinary memory, and his vivid imagination, all played into one another; and he believed himself, as he has somewhere said, capable of reproducing before his mind's eye the minutest details of Roman manners and usages. If he dignified with the name of "divination" the habit in which he freely indulged of guessing where it was impossible to ascertain, great allowance must undoubtedly be made for one whose mind had fed from his youth upwards upon the remains of Roman antiquity, and whose fancy had never ceased for a moment to remark, arrange, and combine their scattered fragments, till they assumed at will every shape it suggested. It is his power of imagination which stamps Niebuhr as a man of the highest genius, and will secure immortality to his name and works. Even the errors of such a man will retain a halo of glory in the eyes of posterity; his methods and principles will continue to command respect and imitation; he will be ranked in a triumvirate of philology with Scaliger and Bentley, to whom he bears no common resemblance in his rapid intuitions and bold combinations—in his sanguine temper and unabashed self-confidence—in his aims, his achievements, and his failures.

The following is a list of Niebuhr's works:—1. Published or prepared for publication by himself:—*History of Rome*, 1st edition, 2 vols., 1812; 2d edition of vol. i., 1827; 3d edition of vol. i., 1828; 2d edition of vol. ii., 1830; 1st edition of vol. iii., 1832; edition of Agathias, 1828, and Merobaudes, 2d edition, 1836, for the *Corpus Hist. Byzant.*; *Kleine Schriften*, 1828. 2. Published since his death, in English and German:—*Lectures in Roman History*, by Dr Schmitz, 2 vols.; second edition of the same, with additions, in 3 vols.; *Lectures on Ancient Ethnography and Geography*, 2 vols.; *Lectures in Ancient History*, 3 vols. 3. To these may be added the *Lebensnachrichten*, a biography of Niebuhr connecting the remains of his correspondence, 3 vols., 1838, with a supplemental volume, containing the *Circular-Briefe*,—a series of letters intended for circulation among his family, written during his residence in Holland in 1808–1809; together with a collection of literary and political tracts from his contributions to periodicals. The first edition of the *History*, 2 vols., was translated into English by Mr Walter; the revised *History*, vols. i. and ii., by Messrs Hare and Thirlwall; the 3d vol. by Drs Smith and Schmitz. An abridged translation of the *Lebensnachrichten* has been given by Miss Winkworth, in 3 vols. (C. M—E.)

Niebuhr ‖ Niemcewicz.

NIEBUHR, *Carsten*, a celebrated traveller, and the father of the great Niebuhr, was the son of a farmer, and was born in the duchy of Lauenburg in 1733. His parents died when he was very young, and left him in the condition of a poor peasant boy. Yet at the age of twenty-one he had raised himself to the position of land-surveyor of his native district, and was busily engaged in studying geometry. The vigorous start which he had thus made in life soon carried him on to higher preferments. While he was deeply immersed in 1758 in the study of mathematics at the university of Göttingen, the Count Bernstorff, the minister of Frederick V. of Denmark, began to carry out a project which had been suggested by Michaelis of sending a staff of scientific men to explore the countries of the East. The place of mathematician was offered to Niebuhr. He accepted the office, but his modesty would not permit him to accept the title of professor, which was intended to add dignity to the office. It was in January 1761 that Niebuhr, in company with Von Haven the orientalist, Cramer the physician, Forskäl the naturalist, and Baurenfeind the painter, set sail from Copenhagen. After exploring the gigantic architectural remains of Lower Egypt, the expedition sailed down the Red Sea, touching at various places on the coast of Arabia, and finally landed and established their head-quarters at Mocha. The rest of the journey was saddened by a series of fatal disasters. All the explorers, with the exception of the judicious Niebuhr, had been persisting in living on European diet, and were now sick unto death. Accordingly, when the expedition set sail for Bombay in 1763, Von Haven and Forskäl were left behind in foreign graves; Baurenfeind was buried at sea; and Cramer died at the end of the voyage, leaving Niebuhr to betake himself homeward alone. He lost no time in re-embarking; and after passing through Persia, Syria, and Asia Minor, and marking these countries with an attentive eye, he arrived at Copenhagen in November 1767. It now became his chief business to lay the results of his travels before the world. He therefore published a *Description of Arabia*, in 4to, Copenhagen, 1772; and *Travels in Arabia and the Circumjacent Countries*, in 2 vols., 4to, Copenhagen, 1774-78. These works were remarkable for their new and correct information, expressed in a plain unaffected style; and they soon brought the author into general recognition. The government at Meldorf in Holstein, made him their land-surveyor in 1778; many learned men throughout Europe began to seek his acquaintance; and the Danish government conferred upon him the cross of Danebrog, and the title of councillor of state, and continued to cherish him till the close of his life. He died in April 1815.

Carsten Niebuhr wrote for a German periodical accounts of *The Interior of Africa*, and *The Political and Military State of the Turkish Empire*, and several other papers. His principal works have been translated from the German into French and Dutch. A Life of him by his eminent son was published at Kiel in 8vo, 1817.

NIEMCEWICZ, JULIAN URSIN, a famous Polish poet and patriot, was born in 1757 at Skoki in Lithuania. His youth was spent in learning the profession of a soldier; and at the age of twenty he entered the Lithuanian army. In

Niemen. his own corps he found Kosciuszko, and imbibed from that noble spirit those patriotic sentiments which gave a direction to the whole of his subsequent career. As early as 1788 his energies and talents had begun to be consecrated to the cause of national freedom. In that same year, as one of the deputies for Livonia, he became one of the great patriotic orators of the Polish diet; in 1791, in conjunction with Weyssenhoff, he started the *National and Foreign Gazette*, to be a vehicle for spreading his opinions; and all the while he was fostering the spirit of nationality among the populace by the poems he published and the dramas he produced on the stage. Nor did his activity slacken at the approach of commotion and peril. In the insurrection that followed the second partition of Poland, he was a most efficient confederate of Kosciuszko, both in the council and in the field. But in October 1794 the disastrous battle of Macieiowice was fought; the cause of the patriots received its death-blow; and among the captives who were carried away and immured in the fortress of St Petersburg, was the zealous Niemcewicz. A check was now put for a time upon his national ardour. For two years he lay in his damp cell, relieving the tedium of his confinement by reading the English poets of the eighteenth century, and by translating Pope's *Rape of the Lock*. On his liberation, there was no resource for him but to repair, with his compatriot Kosciuszko, to the United States of America. There he formed new acquaintances, married a lady of New York, and became domesticated. Yet the welfare of his fatherland still lay next his heart; and the intelligence, in 1806, that Napoleon had espoused the cause of Polish liberty, hurried him back to Europe. He was soon appointed, under the newly-instituted grand-duchy of Warsaw, secretary of the senate, member of the supreme council of public education, and inspector of schools; and in these capacities he began a new career of patriotism. His activity did not flag when the Russians had regained their supremacy over Poland. Though reinstalled by the Emperor Alexander in the high office of perpetual secretary of the senate, he did not hesitate to keep alive, both with tongue and pen, the nationality of the people. In 1816 he revived the memory of the ancient glory of his country by the publication of his *Historical Ballads;* in 1817 he pronounced a funeral oration over Kosciuszko; and in 1822 he began to celebrate the great national heroes in his *Collection of Memoirs on Ancient Poland.* All his efforts were evidently aiming at another revolution. Accordingly, the insurrection that broke out in November 1830 numbered the veteran Niemcewicz among its promoters. He was destined, however, to see the favourite project of his life thwarted once more. The remaining strength of his old age was spent in advancing the cause of his beloved Poland in foreign lands. He died at Montmorency, near Paris, in May 1841.

Besides the works already mentioned, Niemcewicz wrote several tragedies and comedies, novels, historical sketches, and translations from the English poets of the eighteenth century. A complete collection of his poetical works appeared in 12 vols., Leipsic, 1838-40. An autobiographical fragment, written in French, and entitled, *Captivity in St Petersburg in* 1794-96, was published in 1843 by the Polish Historical Committee at Paris, and was shortly afterwards translated into English by Laski. (*English Cyclopædia of Biography.*)

NIEMEN, or MEMEL, a river of Europe, rises in the swampy regions of the Russian government of Minsk, where it is formed by several small streams between N. Lat. 53. and 54., E. Long. 27. It flows first N., and then W., separating the governments of Vilna and Grodno; then, after making a detour through the latter, it divides them both from Poland, and finally flows through Prussia to the Curische Haff, into which it falls by two mouths. It receives from the right the Beresina, the Vilia, the Joura, and other affluents; from the left, the Zelva, Szeschuppe, &c. Its whole length is 450 miles; and, though in some places impeded by shoals, a great part of it is navigable. It is of considerable commercial importance; for most of the produce of Lithuania is conveyed by barges down this river; and all the timber exported from Memel is floated down the same channel. Niemes ‖ Nieuwentyt.

NIEMES, a town of Bohemia, in the circle of Bunzlau, 18 miles N.N.W. of Jung Bunzlau, and 42 N.N.E. of Prague. It contains a fine castle with extensive gardens, a church, town-hall, and school. Linen and woollen stuffs are manufactured here. Pop. (1846) 4181.

NIENBURG, a town of Hanover, capital of the county of Hoya, stands on the right bank of the Weser, which is here crossed by a stone bridge, 29 miles N.W. of Hanover, and about as far S.E. of Bremen. It was formerly fortified, but the defences were destroyed by the French in 1807. There are two churches, a high school, an hospital, several courts of law; linen, cloth, and vinegar manufactures, and some trade in corn and timber. The town has also some river shipping. Pop. (1852) 5052.

NIEUWENTYT, BERNARD, an erudite Dutch philosopher, was born at Wastgraafdyk, in North Holland, on the 10th of August 1654. His father, who was a Protestant clergyman, originally designed him for his own profession; but as Bernard displayed a stronger predilection for science than for the church, he was allowed to follow his own inclinations. He studied mathematics, medicine, law, and philosophy with zeal and success. His confidence in mathematical science, however, seems to have been greater than his skill; for in 1694 he commenced a series of attacks upon the calculus, which increased his notoriety, but did not add to his fame. His first brochure was entitled, *Considerationes circa Analyseos ad Quantitates Infinitè Parvas Applicatæ*, &c., Amst. 1694; a work which he followed up next year by *Analysis Infinitorum seu Curvilineorum Proprietates ex Polygonorum Naturâ Deductæ.* Leibnitz replied to his objections in the *Leipzig Transactions*, to which Nieuwentyt produced a rejoinder in 1696. John Bernoulli defended Leibnitz; and Jacob Herman, in a work published at Bâle in 1700, ultimately silenced the Dutchman, to the satisfaction of all intelligent mathematicians. With the exception of *A Treatise upon a New Use of the Tables of Sines and Tangents*, contributed to the *Literary Journal* of the Hague in 1714, we hear no more of Nieuwentyt and mathematics. In philosophy he was a follower of Descartes, and produced some fresh speculations on the subject of natural theology. He attempted to establish the existence of Deity by proofs drawn from the order of nature and from the marks of design exhibited in the universe. His great work on this subject, and the one which forms the mainstay of his reputation, appeared originally in the *Leipzig Transactions*, and was afterwards published in Dutch, under the title of *Regt gebruyk der weereld. beschovinge*, 4to, Amsterdam, 1716. In the author's own country it went through four editions in as many years. It was translated into English in 1718; into French in 1725; and subsequently into German by two different hands. The English version was executed by John Chamberlayne, under the title of *The Religious Philosopher*, 3 vols. 8vo, London, 1718-19, and 1730. A new interest attaches to this popular work of the solid Dutchman, from the fact only recently made public (see *Athenæum* for 1848, pp. 803, 907, 930), that Paley's well-known *Natural Theology* seems to have been all but copied from it. Not only has the English archdeacon, it is alleged, borrowed the general argument of the Dutch thinker, he has likewise followed his arrangement, appropriated his thoughts, made use of his form, and copied his details, and that without anything like honourable acknowledgment.

Nieuwland ‖ Nièvre.

Paley refers twice in his work to the name of Dr Nieuwentyt, but in such a manner as obviously to decline the general admission of the sources of his information. Paley's celebrated *watch* which he found "in crossing a heath" in 1802, had been picked up "in the middle of a sandy down" in Holland, just eighty-six years before. An attempt to extenuate the guilt of the reverend culprit may be seen in the *Athenæum* already referred to. In addition to his other works, Nieuwentyt left a refutation of Spinoza in Dutch, which was published at Amsterdam in 1720. He had considerable fame in his day as a physician; and his good sense, ready eloquence, and amiable character, won him esteem as burgomaster of the town of Purmerend, and gave him great influence in the provincial states. He died on the 30th of May 1718.

NIEUWLAND, PETER, a Dutch writer, remarkable for the precocity and versatility of his talents, was the son of a village carpenter, and was born at Diemermeer, near Amsterdam, in 1764. Under the humble tuition of his parents, his infant mind took to learning with an instinctive ardour, and he could compose verses and solve geometrical problems before the age of eight. This ardent predilection for two branches of study so dissimilar, continued to be the prominent feature in his opening intellectual character. At the university of Leyden, to which he had been sent through the liberal patronage of Bernard Bosch, he was equally noted for the easy rapidity with which he solved the most intricate problems of the calculus, and the spirited elegance with which he translated the poetry of the classics. When his academical education had been finished, he appeared before the public in 1787 as the author of a treatise on the means of ascertaining the latitude at sea, and in 1788 as the author of a volume of occasional poems. It was not until he had been appointed professor of navigation and natural philosophy at Amsterdam in 1789 that his attention was exclusively devoted to mathematical studies. He published, in 1793, a treatise on the art of navigation, and two papers in Bode's *Astronomical Almanac*. Other subjects of a kindred nature were engaging his mind; and he was acquiring great academical fame at Leyden in the chair of physics, mathematics, and astronomy, to which he had been promoted in 1793, when he was cut off at the age of thirty. Among Nieuwland's poems is an elegy, entitled *Orion*, which became very popular in Holland.

NIÈVRE, a department of France, lying between N. Lat. 46. 40. and 47. 35., E. Long. 2. 50. and 4. 10; and bounded on the N. by the departments Loiret and Yonne, E. by those of Côte-d'Or and Saône-et-Loire, S. by Saône-et-Loire and Allier, and W. by Cher. Its form is that of an irregular quadrangle; its greatest length is 79 miles, its greatest breadth 65 miles; area 2642 square miles. A range of mountains, forming an offset of those of Côte-d'Or, traverses the department from S.E. to N.W., and separates the tributaries of the Seine from those of the Loire. These hills gradually diminish in height towards the N.W. from 2640 feet to 400 or 600 feet high, and are connected with the Côte-d'Or Mountains by the Mountains of Morvan, which extend westwards in the department of Côte-d'Or, and then southwards between Nièvre and Saône-et-Loire. The general height of this chain is 1600 feet; but one of the peaks, called Mount Prenelay, rises to the height of 2904 feet. The main ridge of the mountains of Nièvre sends off numerous smaller branches, which give the country a rugged and uneven aspect. They are all thickly covered with wood, and present a very wild appearance. The geological structure of the south-eastern part of the department is chiefly granitic and schistose, while in the N. the secondary strata are predominant. There are few extensive plains, except at the north-western extremity of the mountains, and on the borders of the Loire and Allier, where there are some tracts of sandy but fertile soil. The Loire enters the department from the S., crosses it towards the N.W., and then flows northward between Nièvre and Cher. Its principal affluents in this department are—the Aron, the Nièvre, and the Nohain, from the right, and the Allier from the left, which merely skirts the department, separating it from those of Allier and Cher. The Yonne rises in the Morvan Mountains, and flows northwards to the Seine, receiving several small affluents. The streams in the basin of the Loire form numerous ponds, most of which are dried up in the summer; and many canals have been constructed by the inhabitants, which are useful for the irrigation of the soil, and for supplying water-power to various manufactures. The soil is in general poor, but it produces enough of grain for the wants of the people. The climate is temperate but moist; and in some parts fevers are common; from which the valleys of the Loire and Allier are protected by the warm and dry winds which blow from the S. and E. Agriculture has in recent years made great progress in the department; rye and flax are the most important of the crops; and vines are grown with success on the banks of the Loire and Yonne. Of the whole extent of the country, about 303,000 acres consist of arable land, 79,000 of pasture land, 15,000 of vineyards, 368,000 of wood, 27,000 of waste land, &c. The timber of the forests contributes in no small degree to the wealth of the department; it consists principally of oak, beech, and maple. The mineral resources of Nièvre are great, and are worked to a considerable extent: iron, copper, and argentiferous lead are the principal metals; and coal, marble, granite, sandstone, flint, &c., are found in great abundance. One of the principal branches of industry in the department consists in the working of the mines and in the smelting of iron; the annual value of the mineral productions is estimated at L.400,000. It has also been calculated that Nièvre contains 126,000 head of large cattle, 285,000 sheep, 48,000 pigs, 4000 goats, 16,000 horses, 1400 mules, and 2500 asses. There is abundance of game in the department. Besides the smelting of iron, for which there are 30 large furnaces, the manufactures of Nièvre consist of linen and woollen stuffs, pottery, porcelain, hardware, and cutlery of an inferior kind. Some trade is carried on in agricultural produce and in articles of manufacture, especially timber, charcoal, mill-stones, iron, steel, copper, tin, cattle, hides, &c. The internal communication in the country is facilitated by two canals, one of which connects the Loire and the Yonne, and has a length of 86 miles in this department; and the other extends alongside of the Loire for 30 miles in Nièvre. The department forms the bishopric of Nevers; it contains 4 courts of the first instance, and 2 courts of commerce; 4 academies, 2 higher communal schools, and 330 elementary schools. The capital is Nevers; and it is divided into 4 arrondissements, as follows:—

	Cantons.	Communes.	Pop. (1856.)
Nevers	8	99	111,612
Château-Chinon	5	59	67,225
Clamecy	6	93	72,977
Cosne	6	65	74,272
Total	25	316	326,086

Nièvre nearly corresponds with the ancient province of Nivernais, which was in early times a county subject to the dukes of Burgundy. Although it never had any historical importance, this country has given birth to several celebrated men. The people are in general lively, industrious, and hospitable; but ignorant, passionate, and much given to pleasure.

Nigdeh.

NIGDEH, or NIDECH, a town of Asia Minor, in the pashalic of Karamania, on a hill 47 miles N.E. of Eregli. It is defended by ancient walls, and by 3 castles; contains several mosques, a Mohammedan college, and some remains of antiquity. Pop. about 5000.

Niger. NIGER, QUORRA, KWORA, or KAWARA, a large river of Central Africa, which has long excited the interest of geographers, and the attempts to explore which have unfortunately, in too many cases, been attended with a melancholy loss of life. The points long undecided regarding this river were—whether the large river in the interior of Africa, first mentioned by Herodotus, and afterwards by Strabo, Pliny, Ptolemy, and others, could be identified with what is now called the Quorra or Joliba, the latter being the name given to it in the earlier part of its course?—whether it lost itself in the great Lake Tschad, or terminated in the Atlantic Ocean?—whether it carried its waters underground through the Great Desert into the Gulf of Syrtis?—or whether it flowed in an easterly direction, and formed a branch of the Nile?

It is now very generally agreed that the modern Niger or Quorra is identical with the Nigeir of Ptolemy and others. Herodotus gives an interesting account of an expedition undertaken by five young men of the tribe of the Nasamones, a Libyan people who occupied the country lying between that of the Garamantes, or the modern Fezzan, and the great Bay of Syrtis. They set out for the interior, and after passing through the inhabited region and the country of the wild beasts, they traversed for many days, in a western direction, the great sandy desert, until they arrived at a country inhabited by men of low stature, who conducted them through extensive marshes to a city built on a great river, which contained crocodiles, and which flowed towards the east. This river was then supposed to be a branch of the Nile; but without going into the arguments for and against, we may give it as the now generally received opinion that they had reached the Quorra at a place where its course is eastward; and some hold that the city to which they were conducted was none other than Timbuctoo itself. Notice is taken of the Niger by Strabo; and Pliny treats of it at considerable length, as the Nigris of Ethiopia, but in a very confused manner, and as an affluent of the Nile. Mela, however, confessed that when the Niger reached the middle of the continent, it was not known what became of it. Ptolemy, who wrote later than the preceding geographers, and was better informed regarding the interior of Africa, lays down as the course of the Niger what corresponds tolerably well with what we know to be the course of the Joliba or upper part of the Quorra. He seems to have considered it as an interior river, having no communication with the sea. The celebrated Arabian geographers Abulfeda and Edrisi, and Leo Africanus, a native of Spain, all assigned to the Niger a westerly course; and the two former represented it as rising from the same source as the Nile; but Leo supposed it to take its rise in a lake situated to the south of Bornou, whence it was believed to flow westward to the Atlantic Ocean.

The early European navigators, in their discoveries on the western coast of Africa, found successively the estuaries of the Senegal, Gambia, and Rio Grande, and believed them to be the mouths of the Niger. In course of time they were tempted to explore these rivers for the purpose of reaching the far-famed city of Timbuctoo, the reputed wealth of which had excited their cupidity. These they traced till they became mere rivulets, and yet found themselves no nearer to the object of their desires. In the meantime the French geographers De Lisle and D'Anville devoted their attention to Africa. De Lisle, in a map published in 1714, gave the sources both of the Niger and Senegal—the former being made to flow eastward and the latter westward, which was an approximation to the truth. D'Anville followed up this view in his map of Africa published in 1749; and thus far a correct knowledge of the source and direction of the Niger was obtained, by its being separated on the east from the Nile, and on the west from the Senegal.

The formation of the African Association in England in 1788 marks the commencement of a new era in the history of African geography, The first and principal object which occupied the attention of this body was the course and termination of the Niger; and a reward was held out to the person who should succeed in determining them. We pass over the names of Ledyard and Lucas, the former having died at Cairo before accomplishing anything; and the latter having only gathered some information from the Arabs, which tended rather to perplex than to elucidate the subject. The third adventurer employed by the association was Major Houghton, who had acted as British consul at Morocco, and had thus become familiar with Moorish manners. He sailed up the Gambia to Pisania, and thence proceeded into the interior, but he there met his death without accomplishing anything of importance. The honour of determining the course of the Niger was reserved for the celebrated traveller Mungo Park. Having offered his services to the association, and been accepted, he, on the 22d May 1795, left England, and on the 5th of July reached Pisania, where he remained for some time to acquire the Mandingo language. On 2d December he began his journey, and after crossing the country E.N.E. to Yarra, and then turning S.E. through the kingdoms of Ludamar and Bambarra, he came in sight of the Niger near Sego. "I saw," says he, "with infinite pleasure, the great object of my mission, the long sought-for majestic Niger glittering to the morning sun as broad as the Thames at Westminster, and flowing slowly to the eastward." He traced its course downwards to Silla, and upwards as far as Bammakoo, an extent of about 300 miles. From the latter place he crossed the country by a more southern route than his former track, and at length reached Pisania on the 10th June 1797. At the request of the British government he undertook another expedition, and set sail from Portsmouth, fully equipped, on 30th January 1805. Pisania was again his point of departure, which he left on the 4th of May 1805, accompanied by his brother-in-law Mr Anderson, surgeon; Mr George Scott, draughtsman; five artificers from the royal dockyards; Lieutenant Martyn, and thirty-five privates of the Royal African Corps stationed at Goree; and a Mandingo, Isaaco, a priest and trader, who acted as guide. He chose the route by which he had returned on his first journey, but he had not proceeded far when the rainy season set in, and by the time that he reached Bammakoo only eleven men remained with him, the rest having either died by the way, or been left sick in charge of friendly natives, but never afterwards heard of. The expedition descended the river in two canoes to Sansanding, where Mr Anderson and some others fell victims to the climate. His last despatches are from this place. Writing to Lord Camden he said:—"I am sorry to say that of forty-four Europeans who left the Gambia in perfect health, five only are at present alive; viz., three soldiers (one deranged in his mind), Lieutenant Martyn, and myself." He added—"We had no contest whatever with the natives, nor was any one of us killed by wild animals or any other accident." He set sail from Sansanding on the 19th November, and from information since obtained, he seems to have proceeded down as far as Boussa, 650 miles below Timbuctoo, where, having been attacked by the natives, he and his companions attempted to save themselves by swimming, but were drowned.

Park had been led to adopt the opinion of Captain Maxwell, a slave trader, who had been accustomed to frequent the Congo, that that river formed the lower part of the Niger. After the time of Park this opinion continued to gain ground, and the government was at length induced, in 1816, to despatch an expedition to attempt the solution of this question. It was divided into two parts: the one, under the command of Major Peddie, was to pene-

Niger. trate across West Africa to the Niger; the other, under Captain Tuckey, to ascend the Congo. These threw no new light on our subject, and were attended with very disastrous results; the commanders and most of the men having fallen victims to the climate. More recently the travellers Laing, Caillie, Clapperton, and Richard Lander ascertained important facts regarding the Niger; but it is to the last of these that we are indebted for having pointed out the true mouth of the Niger. His first journey was undertaken as confidential servant to Captain Clapperton, and on the death of that enterprising traveller at Saccatoo on the 13th of April 1827, he brought home his journal and papers. On his return to England he volunteered to navigate the river from Boussa, the point where Park perished, to its mouth. His offer having been accepted by the government, he set out on his mission, accompanied by his brother John, and reached Boussa on the 17th of June 1830. From Boussa the Landers proceeded up the river about 100 miles to Yaoori, where they arrived on the 27th of June. They commenced the descent of the river on the 2d of August; and on the 18th of November following they entered the Atlantic by the River Nun, and thus set at rest the long disputed question of the mouth of the Niger.

The return of the brothers Lander awakened anew the spirit of enterprise, and an expedition was fitted out by some merchants of Liverpool for commercial as well as geographical purposes. It consisted of two steam vessels, and the general direction of it was intrusted to R. Lander. It proceeded up the Niger as far as Rabba, and likewise for nearly 100 miles up a hitherto unexplored affluent, the Shary or Tschadda. The results of the expedition, however, were unsatisfactory to the projectors, and most fatal to those who had undertaken it, very few of the Europeans having survived. Among those who perished were the two Landers—John from the effects of the climate, and Richard from a wound received in an encounter with the natives. No further attempt of any magnitude was made until 1841, when the government fitted out three steamers built specially for the purpose. This expedition was intended to carry out, besides extended researches, various philanthropic but ill-matured schemes. It shared no better fate than its predecessors, having only reached Egga, about 50 miles above the confluence of the Tschadda, when it was obliged to return in consequence of the sickness and death on board.

In 1852 intelligence was received from Dr Barth, that on the 18th of June 1851 he had crossed a large stream named the *Benué*, or "Mother of Waters," which, from the information received from the natives, he conjectured to be the upper part of the Tschadda affluent of the Niger. He reached it at a point called Taëpe, where it is joined by the Faro, in Lat. 9. 2. N., Long. 14. E., 235 geographical miles S. of Kuka, and 415 in a direct line E. by N. from the confluence of the Tschadda with the Quorra. It was here half a mile broad, and, when crossed, was 9½ feet deep in the channel, but on their return, eleven days later, it had risen 1½ feet. The Faro was five-twelfths of a mile broad, and 3 feet deep, and by their return had increased to 7¼ feet in depth. Both rivers had a very strong current, and flowed westward.

Another expedition was now resolved on to explore the Tschadda branch of the Niger, and the Admiralty entered into a contract with Mr Macgregor Laird, one of the survivors of the Liverpool expedition, to build and equip a suitable vessel for that purpose. Accordingly, an iron screw schooner, named the Pleiad, was built at Birkenhead. "She was of 260 tons measurement, 100 feet in length, with 24 feet beam, and her engine was of 60 horse-power. Her draught of water, when laden, was 7 feet, or 6 feet when in ordinary trim. A sailing-master, surgeon, officers, and crew, were provided for her by Mr Laird, and it was arranged that she should be sent to Fernando Po, where the officers appointed by government should join. The peculiar features of this expedition were, first, the employment of as few white men as possible; secondly, entering and ascending the river with the rising waters, or during the rainy season; and lastly, it was anticipated that the use of quinine, as a prophylactic or preventive, would enable the Europeans to withstand the influence of the climate. Mr Laird being permitted, by his agreement with the Admiralty, to trade with the natives whenever it was practicable, provided a well-sorted cargo, and sent out persons specially to attend to this branch. The Pleiad having made a very satisfactory trial trip across the Irish Channel, finally took her departure from Dublin on the 20th of May 1854." The expedition set out from Fernando Po on the 8th of July, and four days later entered the Nun branch of the Niger. In the beginning of August they reached the confluence of the two great rivers, speaking of which, Dr Baikie says,—"From our anchorage at the confluence, near the Sacrifice Rock, as well as from the heights of Mount Pàtte, the Chàdda appeared a much nobler and finer stream than the Kwòra. The latter seemed small and narrow, and could be seen pursuing in the distance its meandering route from the northward, while full in front comes pouring from the E. the broad, the straight-coursed Chàdda. The natives allege that there is a difference in the colour of the two streams, and hence the Kwòra is named in Hanasa *Fari 'n rua*, or the 'White Water,' while the other is known as *Baki 'n rua*, or the 'Black Water.' I found the temperature of the former to exceed that of the latter by from half a degree to a degree of Fahrenheit." The Pleiad ascended the Tschadda 250 miles above the point reached by the Liverpool expedition, and within about 50 miles of the confluence of the Benué and Faro where crossed by Dr Barth; and returned to Fernando Po on the 7th of November. The party numbered 66 persons (12 Europeans, and 54 persons of colour), and though they had been 118 days on the river, very little sickness had been experienced, and no life lost.

The Quorra, or rather the Joliba, though its source has not been actually explored, is said to rise in Mount Loma, one of the Kong Mountains, in Lat. 9. 15. N., Long. 9. 36. W. Its course is at first N., then N.E. to Curuassa, about 100 miles from its source, where it was crossed by Caillie, and found to be, before the inundation commenced, 900 feet in width and 9 in depth, with a current of 2½ miles an hour. Before reaching Bammakoo, it receives the Tankisso and Sarano, both large streams; and at Bammakoo it commences its course over the plain of Bambarra, flowing still in a N.E. direction. It pursues the same course till it reaches Jenne, when it takes a bend nearly due N., flowing in that direction till it arrives at Lake Dibbie, where it reverts to the N.E., and continues in that direction till it reaches Timbuctoo, where the Quorra proper commences. Caillie navigated the river from Jenne to Timbuctoo, and represents the banks between these places as low and marshy. Below Lake Dibbie, which is of considerable size, the river is very deep, and from half a mile to a mile in breadth, with a considerable current. Near Kabra, the port of Timbuctoo, it divides into two branches; the larger of which is about three-fourths of a mile broad, and the smaller about 100 feet broad, but very deep. They appear to unite at no great distance farther down; but from Timbuctoo to Yaoori very little is known of this great river, except that its general direction seems to be S.E. From Yaoori to the sea it was navigated by the Landers, and was found to flow at first nearly due S., then to take a rapid bend to the E., and afterwards gradually to return and take a S.S.W. direction to the Atlantic, which it enters by 22 mouths, the principal of which is the Nun.

Niger || Nijne-Novgorod.

NIGER, C. PESCENNIUS, a Roman general, was born at Aquinum in Italy in the former half of the second century, and rose from a low rank in the army to be governor of Syria. In this office his graceful and athletic frame, his soldier-like accomplishments, and his rigid enforcement of discipline, secured the esteem of the soldiers; while his mild but impartial rule rendered him a favourite among the provincials. Accordingly, on the assassination of Pertinax in 193, he was proclaimed emperor by the united voices of the people of Asia and his own army. The intelligence that Septimius Severus was also up in arms for the crown soon hurried him into action. He marched westward from Antioch, securing the most important Asiatic cities, and despatching troops to occupy Thrace and Northern Greece. But the chivalrous unsophisticated soldier of Syria was no match for the wily and rapid Severus. His troops were finally routed at the Gulf of Issus, near the Cilician gates, and he himself was sacrificed to the revenge of his victorious rival A.D. 194. (See ROMAN HISTORY.)

NIGRITIA, or SOUDAN "(The Land of the Blacks"), are names applied to the central regions of Africa; and, as used by Europeans, include the country lying south of the Sahara, and north of 6. N. Lat., bounded by Egypt and Abyssinia on the E., and by the nations on the western coast on the W. Until near the close of last century little was known of this extensive country; but in 1790 Houghton, who was the first European traveller in Central Africa, entered Nigritia from the west; and since that time several other discoverers have explored the western and central parts of this region, though the eastern part has not yet been visited by travellers. The principal mountains in Western Nigritia are the Kong chain, which stretches from W. to E. along the south of the country; and the principal river is the Niger, Quorra, or Joliba. The land is generally flat; and being watered by the annual overflowing of the rivers, as well as by the rains, there are some tracts of considerable fertility, on which maize, millet, rice, tobacco, cotton, &c., are raised. The climate is very hot and sultry, except during the rainy season, which extends from August to October. Central Nigritia consists of a mountainous and a flat region, the former lying to the W., and the latter to the E., of the 11th degree of E. Long. The mountains do not probably rise above 1000 or 1200 feet above the sea, and the country between them is occupied with forests and marshes. The level part of this district extends round Lake Tschad, and is watered by its tributaries. It is one of the largest tracts of inland alluvial ground in the world. The soil is very fertile, but the rank vegetation renders cultivation difficult; and the climate, though hot, is not unhealthy. Nigritia is divided into several smaller states, of which the principal are Bambarra, Timbuktu, Houssa, Bornu, Baghermi, Waday, Darfur, and Adamanua. (For an account of these, see AFRICA.)

NIJAR-Y-HUEBRO, a town of Spain, in the province of Almeria, and 14 miles E.N.E. of that town. It is ill built, and has a church and two schools. There are dye-works, and manufactures of woollen stuffs and pottery. Some trade is carried on in corn, cattle, barilla, and cloth. Pop. 5820.

NIJNI-NOVGOROD, or NISHNI-NOVGOROD, commonly contracted to *Nijegorod*, a government of Russia, between N. Lat. 54. 30. and 57. 5., E. Long. 41. 45. and 46. 15. It is bounded on the N. by Kostroma and Viatka, E. by Kazan and Simbirsk, S. by Penza and Tambov, and W. by Vladimir. Its length is 185 miles; greatest breadth, 136; area, 18,680 square miles. The surface is generally flat, but diversified in some places by undulating heights, which nowhere rise above 500 feet from the sea. The prevailing geological formation is limestone, and iron is the only metal found here. A sandy soil, much mixed with vegetable mould, forms the greater part of the surface, which is very fertile, and produces plentiful crops of corn, so as to serve as the granary of Russia. The principal river is the Volga, which traverses the government from W. to E., making a bend towards the S. It receives in the government the Oka, Kulma, Kirsenez, Sara, Verluga, and Alatyr. In 1849 there were 4,689,798 acres of arable land, 729,384 of meadow land, 5,105,469 of wood, and 1,243,109 of waste land. Farming is carried on here in a much superior style to what prevails in most parts of Russia, and the farmers are distinguished alike by their skill and industry. Besides corn, the principal crops raised are hemp, flax, hops, peas, and beans; and considerable care is bestowed on the cultivation of fruit,—apples and cherries especially being remarkable alike in quantity and quality. The forests of this country are a great source of wealth, on account of the abundance of excellent timber which they contain, of which oak, lime, pine, beech, and alder are the principal kinds. The breeding of cattle is also carried on, though not to such an extent as agriculture; and there were in 1849 in Nijni-Novgorod 326,425 horses, 273,863 horned cattle, 475,801 sheep, 121,803 swine, and 1128 goats. The horses are the best that are bred in Russia; and the horned cattle are also of good breed. Although there are but few large manufactories in the government, it is inferior to none in the extent to which the people are engaged in the pursuits of manufacture; for most of the villages are filled with artizans, who produce on a small scale a great variety of articles. Spinning, weaving, and pottery, are chiefly carried on in these small establishments; and among the more extensive productions leather, cloth, cordage, soap, candles, iron, steel, &c., are the principal. There is an active trade in the exportation of corn, flour, hemp, flax, horses, and manufactured articles; and the importation of iron, salt, brandy, wine, &c. The commerce of the country is greatly facilitated by the large navigable rivers by which it is traversed. Pop. (1849) 1,124,251. Nijni-Novgorod

NIJNI-NOVGOROD, the capital of the above government, stands at the confluence of the Oka with the Volga, on the right bank of the latter river, 259 miles W. by N. of Moscow. It consists of three parts: the upper city, which stands on a hill between the two rivers; the lower city, which extends along the bank of the Volga; and a suburb, stretching along that of the Oka. The highest part of the upper city, which immediately overhangs the river, is occupied by the kremlin or citadel, which is surrounded by a lofty wall flanked with towers, and contains the principal buildings of the town. These consist of two cathedrals; the governor's palace, a modern building, commanding an extensive view; a Protestant church; and other public edifices. The town itself is pretty well built, though for the most part only of wood. There is an irregular public Place in the upper town. Nijni-Novgorod has 42 churches, 3 convents, a seminary for schoolmasters, and several schools. Manufactures of malt, beer, leather, cloth, soap, candles, copper and iron ware, &c., are carried on; but the chief importance of the place is derived from the great fair which is held here annually, and lasts from the latter half of July to the end of August. The place of these fairs is a low tract of ground, of a triangular shape, lying between the Volga and the Oka, and separated from the town by the latter river. At all other times of the year this place is quite deserted, and sometimes overflowed by the rivers; but as the fair is held at the dry season, it is then in no danger of this, and always presents a very busy and animated scene. It is laid out in broad and regular streets, crossing each other at right angles, and having in general covered arcades of iron along the sides in front of the shops. It is drained by a system of underground sewers, made of hewn stone, at a great cost. Access is gained to them at several points by means of staircases; and water is con-

Nikolaiev ‖ Nile.

veyed through them from the rivers several times a-day. The only communication with the town is by means of a bridge of boats across the Oka. The governor of the province resides during the continuance of the fair in a handsome building in the centre; and there is a Russian church and a Mohammedan mosque within the precincts of the fair. This part of the market is entirely built of stone, and contains 2521 shops, forming 60 blocks of buildings. This forms the inner market, and it is separated from the outer by a canal, which is crossed by four bridges. The outer market is built of wood, and contains upwards of 2000 booths, built in a very substantial manner. In the inner market are to be found chiefly the more valuable articles of manufacture; such as cloth from Moscow, silk from Persia, furs from Siberia, Astrachan, Buchara, and other places; tea from China; and other goods. Here also there are not such great crowds collected as in the outer market, but the most extensive business transactions are carried on. The outer market, which has more the character of a fair, is generally much crowded with people from all parts of the world, and contains most of the raw material and articles of small value. The rivers during the continuance of the market are crowded with vessels of all sorts and sizes, busily engaged in loading and unloading their cargoes; and a great number of people live entirely on the water. The whole number who attend the market, from first to last, is estimated at 200,000; those collected together at any one time being not more than 20,000. The amount of articles bought and sold is immense. The quantity of iron collected here in 1843 was about 60,000 tons; of copper, 800 tons, valued at more than L.200,000; besides which there were 39,000 chests of tea, and many other articles. Pop. of the town (1849) 30,710.

NIKOLAIEV, a town of Russia, in the government of Kherson, occupies a large extent of ground at the confluence of the Ingul and the Bug, 36 miles N.W. of Kherson. It has wide and regular streets, lined with very well built houses, one storey high, which have in general large gardens attached to them. It is surrounded by fortifications; and has a fine boulevard, planted with trees, along the edge of the river. The public buildings are numerous; and among them the most important are,—the cathedral, a modern edifice with a richly-decorated interior; the town-hall; the observatory; the admiralty; the naval barracks; and naval hospital. The dockyards are very extensive, and provided with machinery principally of British construction. The town has also numerous schools for naval cadets, pilots, ship-builders, &c. Nikolaiev is the principal station of the Black Sea fleet, and the residence of the admiral of it. It was founded in 1791, and at first made rapid progress; but it is now in a declining state, owing to the want of good water and timber, the competition of Odessa, and other causes. It is now kept up principally by the support of the government. Pop. (1850) 39,338.

NIKOLSBURG, a town of Moravia, in the circle of Brünn, and 27 miles south of that town, is built round the foot of a rock, on which stands a castle flanked with high towers. It has ill-paved and dirty streets; and the principal buildings are, a handsome church, two synagogues, and a Piarist college. Manufactures of woollen and linen cloth are carried on here. Pop. 8000.

NILE. The whole subject of the geology, inundation, levels, volume of water, deposits, and agricultural action of the Nile in the northern portions of its course, has been so very fully treated of in the article EGYPT (see vol. viii., pp. 424-6), that we shall confine ourselves in the present article to the southern and less known portions of this great river, and endeavour to throw some further light upon its probable sources and course—that great problem which has puzzled the geographers and men of science in all ages, and baffled the attempts of the ancient priests of the Nile, of the Pharaohs, of the Phœnicians, the Greeks under the Ptolemies, the Romans under the Cæsars, and, in much later times, of Bruce, and the numerous expeditions under Mohammed Ali and Ibrahim Pasha.

Nile.

The general features of the Nile, as you ascend it from the second cataract at Wady Halfa to the junction at Khartoum, undergo no material change. From time to time the river flows through high rocks of dark syenite, and four cataracts (more properly called rapids) impede its smooth course for a few miles; but a detailed description of its banks would be uninteresting: desert wastes and fertile islands—sandy hills surmounted by doum palms (here taking the place of date trees), and narrow strips of luxuriant vegetation—villages deserted by a too-heavily taxed population, and large towns, the capitals of their provinces,—characterize the scenery. The crocodile increases in number, as in size, and the ibis begins to appear. Near Berber, about 100 miles north of Khartoum, the hippopotamus ceases to be a rarity, and the white crocodile is occasionally to be seen.

Wady Halfa to Khartoum.

In Lat. 21. N. the river makes a great bend to the eastward, and the traveller southwards crosses the desert of Bayiouda, which skirts the western banks of the Nile, a most beautiful ride of 250 miles through a garden rather than a desert. The path lies through woods of good-sized trees—mimosas, myrtles, acacias, hung with tropical parasites; while the ground is covered with the senna, colocynth, ice-plant, and many strongly-scented shrubs. From the dead roots of fallen trees rich orchids spring, and an infinite variety of gay-coloured birds are flitting about over head. Partridges and gazelles of several descriptions abound, and the whole country is thickly peopled with many tribes, who are in the habit of travelling from well to well, accompanied by large herds of sheep, goats, and camels, in search of pasture.

Desert of Bayiouda.

The great desert of Nubia borders the eastern bank of the Nile, and is of a very different description. With the exception of some high rocks of quartz and granite, near the well of El-Morah, the route from Aboohamed to Korusko, a distance of 350 miles, lies through a perfectly level, hard, gravelly plain; no vegetation of any sort exists, save on the immediate banks of the river, and the only well is that of El-Morah, above mentioned.

Desert of Korusko.

After a journey of twenty-five to thirty days from Wady Halfa, partly in boats, but chiefly on camels, the traveller reaches Khartoum, the capital of Nubia, and the seat of government of the "provinces of the Soudan." The town contains about 30,000 inhabitants; but with the exception of the governor's palace, and one or two harems connected with it, there are no buildings in it of any importance. The gardens are most prolific: pomegranates, lemons, limes, oranges, grapes, cream-fruit, bananas, prickly pears, figs (two crops), and garden vegetables of great size and luxuriance (salads, cucumbers, potatoes, radishes, &c.), are to be had here in abundance. The trade in gum and slaves is the only very important one. There is also a small export trade in gold, ivory, and ostrich feathers; while glass beads, gunpowder, and Manchester cotton goods are the principal imports of this city, which supplies the vast territories of Sennaar, Darfur, and Fazokl. The net revenue of these provinces is said to amount to from L.200,000 to L.250,000 per annum, which is remitted to Cairo, after deducting the various expenses of government, collection, and of the standing army. The latter consists of 15,000 infantry, 5000 cavalry, and 24 pieces of artillery. The governor enjoys a more than viceregal power;—at once commander-in-chief of the army, and chief judge over these provinces. Latif Pasha, who was the governor in 1850, told the writer that he was in direct or indirect communication with 30,000,000 subjects; but as we found him ignorant of the number of tribes inhabiting the immediate districts

Khartoum.

Nile.

round Khartoum, no great reliance can be placed on these figures, except in so far as they confirm all the accounts we have of the immense population of the banks of the White Nile. There is no reason to suppose that these nations are badly governed, though they appear somewhat over-taxed in certain districts; for the rulers of the southern provinces of Egypt are all men of great ability,—and, for Turks, of rare intelligence,—in fact, they have, almost without exception, received these high preferments as a species of transportation for being too European and civilized in their ideas. Latif Pasha was an intimate friend of Linant Bey, Clot Bey, and Lambert Bey, all of whom were in great disgrace, and some of them in the same sort of honourable banishment, during the latter part of the reign of Abbas Pasha, the late viceroy of Egypt.

The city of Khartoum is situated in Lat. 15. 37. N., and Long. 33. E. from Greenwich, within 250 yards of the confluence of the White and Blue Niles, the Bahr-el-Abiad, and the Bahr-el-Azrek. From this point the Nile flows 1500 miles ere it reaches the Mediterranean; and with one exception, that of the small tributary the Atbara or Tacazze (a stream which may be waded across in the dry season), not one drop of water falls into it; while it supplies the innumerable *shadoofs* of Nubia, the thousands of *sakias* which water the land of Egypt, and the hundreds of canals which irrigate the country below Assiout; and, after its long journey of 1500 miles, moving along at the rate of from 1½ to 3 miles an hour, exposed to the evaporating influence of the rays of a never-clouded sun, pours into the sea, through the Damietta and Rosetta branches alone, a volume of water amounting to from 151,000,000,000 cubic metres to 706,000,000,000 cubic metres per diem according to the season.

Cause of the inundation.

The most superstitious and uneducated of the Arabs at Cairo still believe that one drop of water falling upon some particular rock in Abyssinia causes the inundation of the Nile; but the real cause of the annual overflow is well known to be the very heavy rains which take place in the south during the months of June, July, and beginning of August. The traveller, ere he reaches the junction of the two Niles, will have already seen some traces of these heavy falls of rain. In the desert of Bayiouda, 150 miles from the river, the sides of each ridge of ground are marked with miniature river-beds; every little valley has a damp spot, where, for a few weeks, a small lake was collected; and his path is often traversed by deep water-courses, now long since dried up. At Khartoum the rains are described as lasting for four or five weeks without intermission, the streets are turned into rivers, the public square into a lake, and many of the mud-walled houses fall in, though the river does not overflow its bank on that side. In 1850 the Azrek rose at Khartoum as much as 18 inches in one night. Violent as these rains seem to be, there is no doubt that further south they are much more violent, and of much longer duration. The two branches of the Nile rise at about the same time. The Blue Nile, during its tortuous course, is fed by the various streams which flow from the mountains of Abyssinia, and the Atbara collects the rain which falls on the high ground situated to the N.E.; but by far the largest body of water comes down by the White Nile from the marshes and lakes in Lat. 6. to 10. N., and from the original mountain sources yet farther S.

Blue Nile.

The sources of the Blue Nile, or Bahr-el-Azrek, as we know by the discoveries of Bruce, consist of three large springs among some mountains 6000 feet above the level of the sea, situated, according to his calculations, in 10. to 11. N. Lat., and 36. to 37. E. Long.; thence the river flows through the Lake of Izana or Dembea, known to Ptolemy by the name of *Kaloe*, and pursuing a most circuitous course (at one time almost returning to its original source), collects all the streams running down from the mountainous regions of Gojam, and flowing northward through a series of cataracts or rapids, descends into the district of Fazokl, where the gold mines of the Pasha of Egypt are situated. There, having been enlarged by the influx of the Jumet from the S.W., the river reaches the plains of Sennaar by another series of cataracts and rapids. The natural bed of the river at Khartoum is half a mile in width, and the water in the dry season from 400 to 500 yards wide. In the inundation it rises from 18 to 24 feet in height, and is from 1 to 1¼ mile in width. The water flows very rapidly when compared with the White Nile, and opposite Khartoum is clearer, fresher, and sweeter, than after its junction with the latter.

Nile.

White Nile.

The sources from which we might draw our information as to the White Nile are very numerous, but as very few of those who have ascended this branch of the Nile above Khartoum have taken reliable observations, and as no two accounts are easily reconciled, our task of selection is no easy one. We shall, however, briefly glance at the travels and opinions of the most trustworthy pioneers.

Opinions of Browne.

Browne penetrated to the south of Darfur, and believes that the actual sources of the Bahr-el-Abiad are situated in 7. N. Lat., and consist of many streams flowing from the Mountains of the Moon, which he places in 6. N. Lat., 4 degrees N. of the point to which the Nile has since been ascended. This is a revival of the opinion of Ptolemy, and we believe the correct one,—"The Ethiopian Anthropophagi dwell around this gulf, which is skirted on the west by the Mountain of the Moon, from the snows of which the superabundant waters of the Nile are drawn." (Ptol., *Geogr.* iv. 8.)

Linant Bey.

Linant Bey, travelling for the African Association in 1827, surveyed the course of the river a direct distance of 132 geographical miles, from Khartoum to about Lat. 10. N. He describes the river as in many places 1½ mile wide, while its banks seemed often as much as 4 miles apart; and asserts that when the river is at its greatest height it overflows its banks a distance of 20 miles on each side. The general appearance of the country is flat; the eastern side is desert, while the western banks are covered with vegetation, stretching inland. Farther south, the river becomes narrower, and the depth increases to from 6 to 8 fathoms. From information obtained at the most southern point of his journey, he seems to be of opinion that the White Nile rises from a system of lakes, and he advances, in defence of this view, two facts,—1*st*, That neither gravel nor sand, indicative of its being fed by torrents, are found in it, and that the clayey nature of its shoals proves that it does not come from mountains; 2*d*, That the prodigious quantities of fish which arrive at Khartoum by the first freshes could only have come from lakes, where they had been imprisoned during the low water, and from which they escape when the heavy rains commence.

Hoskins.

Mr Hoskins believes that the source of the Nile could only be discovered by means of an armed force, and that it would require a large army to subdue the great extent of country through which the Bahr-el-Abiad passes. He thinks that not only the chiefs, but the whole population, instead of any of them joining the standard of the invader, or furnishing him with provisions, would resolutely oppose him; each man would fight for the preservation of his property, family, and liberty.

Colonel Leake.

Colonel Leake observes that, if man-stealing had not been the principal object of the numerous Egyptian expeditions up the White Nile, they would have been more successful in penetrating to its sources. He seems to be of opinion that a route by water in the direction of the sources of the Nile is afforded from the westward by means of the newly-discovered branch of the Quorra (the Shary), which is a mile and a half wide at its junction with the Quorra, and is navigable for a great distance above the confluence.

Nile. As the Shary, where crossed by Dr Barth, in Lat. 9. 2. N., Long. 14. E., was found to be about half a mile wide, this hypothesis is not an unnatural one. The most ancient authorities uniformly maintain that the Niger and the Nile are connected together; and it has ever been a favourite opinion with the Egyptian race that the Nile flows from the sea through the centre of Africa, is lost in the sands of the great desert, and re-appears in the country of the Shellucs.

Werne. Mr Werne, in his work on the White Nile, gives a most detailed account of his travels southward to about 4. 30. N. Lat. He formed part of the great expedition in 1840 of which Ahmed Pasha and Suliman Kashef were the chiefs, and MM. Arnaud, Thibaut, and Sabatier the principal Europeans. The expedition consisted of 10 vessels mounting 10 guns in all, and manned by 260 Negro, Egyptian, or Syrian sailors and soldiers. They set sail for the southwards from Khartoum on the 23d November 1840. As they proceeded, they found the left shore wooded with a girdle of copsewood and large trees, extending just as far as the annual inundation; while on the right shore the bare stony desert extended to the horizon. In Lat. 14. 35. N. the river, now 3 miles broad, becomes studded with fertile islands. They sail past the islands of Genna, Sial, and Salahieh, swarming with three distinct tribes of monkeys; in the mud where they anchor, large river snails and oysters are found; the low banks of the islands are trampled with hippopotamus footprints; among the trunks of the trees, still standing in the water, large white aquatic flowers glisten, and the beautiful double lotus, sacred to the temples of Lower Egypt, here first appears; the sun sinks behind the mountains of Hassanieh, and the roar of the lion resounds on the eastern bank.

Twelve days' sailing brings them to where the great population of the banks of the White Nile begins. At one moment 15 to 18 villages, with their round mud houses, each containing from 6 to 8 inhabitants, are in sight; a few minutes after, a bend of the river opens 20 to 25 more to the view—many of them containing from 200 to 300 houses. As far as the eye can reach, vast fields of corn stretch to the eastward, speckled with habitations; while the western side continues flat, and forms an immeasurable grassy sea, the limit of which is undiscernible from the masthead. A few hours farther on, they sail through a perfect sea of lotus, the whole river for many miles being white with these beautiful flowers. Flocks of guinea-fowls fly overhead, and geese, ducks, and many varieties of fresh-water fowl abound. They proceed past forests of tamarisks and lately covered pasture land, thickly peopled with the dark handsome Shelluc or Bakhara tribes, to where (Lat. 10 N.) the river winds in two vast streams round a large island of marshy meadow land, 6 miles from side to side, and nearly 20 long—forming no doubt the bed of the river in the inundation season. When again on the united stream, they find the number of villages undiminished, but they are now shaded by the African giant-tree (*Adansonia digitata*), and in the woods the gum-bearing mimosa seems crushed by the slender aspiring Dhelleb palm, here taking the place of the Doum palm of Berber. At one moment six ostriches are in sight on the western bank, and sixteen white crocodiles are seen basking on the mud islands in the middle of the stream. As they reach the River Saubat (Lat. 9. N.), near the mouth of which 17 new Shelluc villages appear, they see a large city 9 miles off, on the confines of a fertile grassy plain, covered with huts and cattle. On the western bank, two giraffes are quietly browsing; and 35 villages, containing from 120 to 600 inhabitants each, are remarked at one moment.

Marshes. In Lat. 9. 4. N. all this population and fertility ceases, and the marshes begin. The bottom of the river is covered with black moss, the current falls to half or even a quarter of a mile an hour, and the air is alive with every species of mosquito and gnat; not a breath of air fills the sails; the heat is most oppressive, every sign of firm ground vanishes, no tree, no village is in sight, and for days they row on in a sea of grass, the burning sky above them. The only sounds are the trombone gruntings of the numerous hippopotami, as they wallow among the dank grasses. The gnats are merciless—no protection from them can be devised, and there is no rest night or day from their attacks; sickness appears—many of the crew die, and Mr Werner is himself insensible for four days. The papyrus, 15 to 20 feet high, and 2 inches thick, bearing on the top a corolla or tuft, branching out in rays, as depicted in the temples, though found in no other part of Egypt, is abundant here. This is the part of the journey up the White Nile which has proved fatal to the success of so many expeditions. The crews have generally revolted, and refused to proceed any farther, or the chiefs of the party have fallen ill, and ordered a return. Nile.

At last they emerge into a canal 100 yards broad, surrounded by high reeds; the banks seem to be of a soft green colour, formed by pale green aquatic plants—lilac convolvulus, moss, water-thistles, and a kind of hemp—in which the yellow ambac tree flourishes, hung round with luxuriant deep-yellow creepers. Few land birds are to be seen, but the pelican, the black ibis, and the dark-red stork are not uncommon. The river winds so much (Lat. 7. 48. N.), that a boat which is four hours ahead seems to be moving along parallel with the rest of the expedition, and the progress is thought good when they make 2 miles due south in 24 hours. Again (Lat. 6. 42. N.) villages appear, and city succeeds city in the pasture land in the interior on both sides of the river, and the shores are lined with an innumerable population. A small army of elephants, with the white paddy birds sitting on their backs, are shaking the branches of the Dhelleb palm for its fruit; and the giraffe watches them from the borders of the desert.

Shortly after entering the kingdom of Bary the expedition was guilty of a rash brutality, which, had there not been a good wind at the time, enabling them to push forward, might have led to the most disastrous consequences. The Turks quarrelled about some exchanges with the defenceless natives, and fired among them, killing and wounding 20 or 30 men and women. The natives are of course not able to distinguish between the Turkish soldiery and Europeans; and as each Turkish expedition robs and murders without scruple, the natural timidity of the Negroes daily increases, and thus casts further difficulties in the way of peaceful traders. The European portion of the expedition seem to have behaved pretty well towards the natives, but were, as we see from the three published accounts, quarrelling with one another the whole time, and would never have proceeded as far southwards as they did, had they not been under the command of a stolid, obstinate, and indifferent Turk. From Lat. 6. to Lat. 4. 30. N., the river winds among fertile fields covered with habitations, and the horizon is bounded on the east, west, and south by high mountain-ranges—the Alps of Central Africa. In 4. 30. N. Lat., on the sixtieth day's sail from Khartoum, their progress was arrested by ridges of gneiss rock running across the river, and forming a rapid not unlike the second or third cataracts in Nubia, and which it would have been in vain to attempt to pass without unloading their *diabehies*. In a country rendered hostile by their own misdeeds, this would have been very dangerous; and having stayed at this point for three days, they made sail northwards. The river was at this point 323 feet across, and seemed to stretch S.S.W.

During their stay, Lakono, the King of Bary, one of the most powerful rulers of Central Africa, and his wife, paid a visit to the commander, Selim Capitan. He arrived escorted by about 1500 Negroes, all armed, naked, painted

Nile. red with ochre, and wearing plumes of ostrich, guinea-fowl, or cocks' feathers among their hair. Lakono wore a long and wide blue cotton shirt, and on his head an oval network cap covered with black ostrich feathers; his neck, arms, and legs were ornamented with rings of iron, red and yellow copper, ivory, and glass beads. In height 7 feet; the face oval; the forehead arched; the nose straight or curved, with rather wide nostrils; the mouth full, like that of the ancient Egyptians, as sculptured in the temple of Aboosimbel; the orifice of the ears large; and the temples a little depressed: he may be taken as a type of his tribe. His queen was most simply attired in two red leather aprons; the head was close shaved; and she wore her usual ornaments of iron, copper, and ivory round her neck, arms, and ankles. The king, and indeed most of the court, towered above the heads of their Turkish and Christian entertainers, being all from 6 feet 6 inches to 7 feet high.

This tribe do not believe in a future life, but acknowledge one great invisible spirit, the creator of all things. They believe that he sometimes visits a particular tree or rock in the shape of a bird or lizard, and here a dervish or hermit priest dwells, to whom the tribe come, laden with presents, to consult as to their domestic, commercial, or warlike affairs.

Lakono told Mr Werne, that in thirty days (travelling) from this point, the Abiad separates into four shallow arms, and the water only reaches up to the ankles; but whether these four brooks flow from the mountains or spring from the ground, he could not say. He seemed positive that there was no snow on these mountains, and they had great difficulty in making him understand what snow was. This seems to upset the theory that the *melting of the snow* on the mountains is a cause of the inundation.

On the 28th of January the expedition began their return, and after eighty-three days' sail they arrived at Khartoum.

M. Rollet. M. Brun Rollet, whom the writer of this article had the pleasure of seeing in Khartoum, has on several occasions penetrated as far as the 5th and 6th degrees N. Lat., and once reached the mountain of Garbo (3. N. Lat.), the highest point to which the Nile has been ascended.

From this place (he says) there is every reason to believe that the river, becoming less and less, could be traced about 3 or 4 degrees to the southward, to the foot of the mountains of Komberat, on the equator. The Kuendas, inhabitants of these latitudes, say, that from this chain of mountains flow two small streams which unite in the village of Lokaya, S. of Robenza, at which spot the river may be crossed on the trunk of a fallen tree. These natives could not be made to comprehend what snow was.

Trade. M. Rollet has devoted himself for many years to trading with the natives on the banks of the Misslad or Keilak, Saubat, and White Nile. Adopting their costume and speaking their language, he has resided among them year after year, exchanging beads and iron, against gum, ivory, and gold-dust. He has a very high opinion of most of the tribes with whom he came in contact, and believes much in the value of the commercial relations which might be established with them. Once promote commerce (says M. Rollet), by protecting the navigation of the river and the property on the banks, and vast pecuniary advantages would accrue to the Egyptian government; for the three principal tributaries of the Nile are navigable almost to their sources. By the Saubat, the foot of the mountains of Imadon, on the southern confines of the kingdom of Cafa, may be reached; there a large trade in ivory, gold-dust, gum, cotton, and feathers, might be established with the nations living on the banks of the river, the Gallahs, and the tribes living to the S.E. of the Adehs.

The exchange of iron for ivory, which amounted to 20 tons in 1845, has risen to 100 tons in 1851; the export of gum has increased much more. When once the Keilac has been ascended to Lake Fitry, will not (asks M. Rollet) the route of the White Nile monopolize and treble the vast export and import trade which has now to pass through the great desert from the sea at Tripoli and Morocco to Bornou, Ouaday, and Bagharmi? The cataracts of the lower Nile will always prove a barrier to any very large extension of commerce, but a railway from Assuan through the desert of Korusko would bring those rich countries to within ten days' journey of Cairo. All these vast tribes—the Denkas, Shellucs, and Barys—would sooner or later become tributary to Egypt, the slave trade raging between them would be abolished, and the ancient country would regain the high rank which she enjoyed under the most powerful and prosperous of the Pharoahs. If this sounds enthusiastic, we must remember that these are the opinions of a quiet middle-aged man, a clever and successful merchant, who has lived for twenty years in Southern Africa engaged in the trade, and living among the people of whom he speaks. Nimeguen.

Much hope was entertained by all those who are interested in the subject, either on commercial or on geographical grounds, of the success of the great expedition for the discovery of the sources of the Nile, which left Cairo last spring with flat-bottomed steamboats, and all necessary appurtenances; but the premature return of Mr A. W. Twyford, the only Englishman of the party (June 1857), with the news that the expedition was stopped by orders from Said Pasha at Meroë, near the Fourth Cataract, has disappointed all the expectations that had been formed.

The source of the Nile is therefore still unvisited; but after reading the interesting travels of Messrs Werne and Rollet, we can almost answer the question asked by Tibullus 1400 years ago—

> "Nile pater quanam te dicere causa?
> Aut quibus in terris accoluisse caput?"

We may assume that the sources of the Nile consist of two or more mountain streams, flowing from the mountains of Kombirat, on the equator, or half a degree south of it; thence it flows northward to Lat. 9. N.; there it receives the tributary streams of the Misslad or Keilac from the westward, and the Saubat from the eastward; thence, stretching in a north-easterly direction, it reaches the city of Khartoum, about 1500 miles from its source, where it is joined by the Bahr-el-Azrek, or Blue Nile; a few miles further on it is increased by the waters of the Atbara, whence it flows onward through Nubia; thence past the First Cataract into Upper Egypt at Assuan, past Cairo to the Barege; whence, diverging into two great branches, it falls into the Mediterranean through the Damietta and Rosetta mouths.

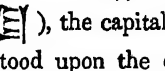
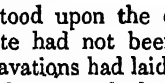
The writer of this article has drawn his information from personal observation, and from the following works, especially from the last three named:—Miss Martineau, *Eastern Life;* Captain Neel, *Nubian Desert;* Wilkinson, *Modern Egypt;* John Kenrick, *Ancient Egypt;* Clot Bey, *Aperçu Générale sur l'Egypte; Journal of the Geographical Society;* Hoskins, *Travels in Ethiopia;* A. Melly, *Lettrés d'Egypte et de Nubie*, 1852; M. Brun Rollet, *Le Nil Blanc et Le Soudan*, Paris, 1855; Ferdinand Werne, *Expedition to discover the Sources of the White Nile*, London, 1849. (G. M.)

NIMEGUEN, or NYMEGEN, a town of Holland, in the province of Gelderland, stands on the Waal, 10 miles S.S.W. of Arnheim, and 53 S.E. of Amsterdam. It is surrounded by fortifications in the form of a crescent, and entered by ten gates. The church of St Stephen is a Gothic edifice in the form of a Greek cross, and contains some interesting monuments. There is also a town-hall, built in 1554, in the *Renaissance* style, and adorned in front with statues of the German emperors who have conferred benefits on the town. In this hall was signed the treaty of 1678 between Louis XIV., Charles II. of

Nîmes ‖ Nineveh.

Spain, and the Dutch States. On a hill near the town are a few remains of the castle of Valkenhof, said to have been built by Julius Cæsar, and occupied by Charlemagne. Nimeguen has numerous churches, an hospital, military watch-house, barracks, arsenal, theatre, and prison. There is a large market-place; and on an eminence stands the Belvedere, a lofty summer-house built by the town, and commanding a fine view. Nimeguen is famous throughout the Netherlands for beer; and it also manufactures leather, hardware, stoves, glue, Prussian blue, soap, painted glass, &c. There is a harbour in the river protected by a wall; and a considerable transit trade is carried on. Pop. (1850) 21,272.

NÎMES. See NISMES.

NINEVEH (Heb. נִינְוֵה; Gr. Νῖνος, Νινευΐ; Lat. *Ninus, Ninos, Nineve;* Arab. نينوى; in the Assyrian cuneiform character probably  , *Ninua;* or (?) sometimes ), the capital of the ancient Assyrian empire. It stood upon the eastern bank of the Tigris, but its exact site had not been satisfactorily determined until recent excavations had laid bare some of its principal ruins. Tradition, however, had attached the name to a considerable group of mounds, supposed, until lately, to be mere heaps of earth and rubbish, near the Arab town of Mosul. Nineveh offers almost a solitary instance of a great and renowned city having entirely passed away previously to what may be termed the historic period. It did not survive the empire of which it was the capital. Both perished together about a century and a half before the birth of Herodotus, the father of history. Even the very ruins of its great national monuments seem to have disappeared before any pen could describe them. The Greek geographers collected some fabulous stories concerning the magnitude and duration of the empire, and the extent and magnificence of the capital; but the only contemporary notice of either is to be found in the Bible, and the details afforded by the Sacred records are few and meagre. It is, however, its connection with the Jews, with the fulfilment of prophecy, and more especially with the events of the first Captivity, that renders the history of Nineveh of so much interest.

The earliest biblical mention of Nineveh is to be found in the 10th or genealogical chapter of Genesis. It is there placed among the primitive cities built after the dispersion of mankind, and its foundation is attributed to Nimrod or to Asshur, according to the different reading of the Hebrew text, which leaves it somewhat in doubt whether the latter name applies to an individual or to the country of Assyria. It would appear from the context that the Jews believed it to have been built and inhabited by the same race that raised Babylon, from which city the Ninevites were a colony. The next allusion to it, according to the generally received chronology, would be in the book of Jonah, B.C. 850; but some German critics have shown that that narrative could scarcely have been compiled earlier than the fifth century B.C., and consequently long after the destruction of the city. It is there described as an "exceeding great city, of three days' journey," containing "more than six score thousand persons that cannot discern between their right hand and their left, and also much cattle." Nahum, when foretelling its approaching fate, about 720 B.C., alludes to its vast riches of silver and gold (ii. 9), and the multitude of its great men and merchants (iii. 16, 17). It is next mentioned in Isaiah as the residence of Sennacherib, the King of Assyria, about 710 B.C. Zephaniah prophesies its impending ruin; and this is the last allusion to it we find in Scripture as an existing city. In the apocryphal books it is spoken of as the dwelling-place of Tobit and his family, and in Judith as the capital of Nebuchodonosor, King of Assyria.

Zephaniah prophesied in the reign of Josiah, the date of whose death may be fixed about 609 B.C. Jeremiah (xxv. 18–26) enumerating, in the first year of the Captivity, or about 605 B.C., "the kings of the north far and near, and all the kingdoms of the world," omits from the list Assyria and Nineveh. It has been presumed, therefore, that both empire and city had ceased to exist, and that their fall had taken place between 609 and 605. This date is remarkably consistent with the statement of Herodotus, that Cyaxares conquered the Assyrians after the expulsion of the Scythians from Western Asia,—an event which did not occur, according to the most accurate computation, until 606 B.C.; the precise date which may therefore be assigned with some confidence, as founded upon the concurrent testimony of sacred and profane history, to the ultimate destruction of Nineveh. (Clinton, *Fasti Hellenici*, i. 269.) It would appear, however, from the statements of Greek writers, that about two centuries and a half before that period the city had been devastated, if not destroyed, by Arbaces, King of the Medes, upon whose successful invasion of Assyria, Sardanapalus, the last monarch of the ancient Assyrian dynasty, burnt himself with his wives and riches on the funeral pile, according to the well-known Greek legend. Although Abydenus places this event 67 years before the first Olympiad, or 843 B.C. (Euseb. *Chron.* i. 12), it has been confounded with the final overthrow of the empire, which occurred 237 years later, upon the invasion of Assyria by the combined armies of Cyaxares, King of Persia and Media, and Nabopolassar, King, or more probably Satrap, of Babylon, who had rebelled against the King of Assyria. Many ancient writers bring the Assyrian empire to a close with the death of Sardanapalus. To reconcile this confusion of dates and events, it has been conjectured that there were two kings of the same name, and that the second Sardanapalus, who was also called Saracus, was the last of the second dynasty, and, like his predecessor, destroyed himself with his palaces and wealth when his capital was about to fall into the hands of his enemies. Josephus, on the other hand (*Ant.* ix. 11, 3), distinguishes between the extinction of the Assyrian empire and the fall of Nineveh; the latter he places 115 years after the date of Nahum's prophecy, or about 626 B.C.; the former (x. 2, 2), in the reign of Hezekiah, probably on the murder of Sennacherib by his sons, or 710 B.C. Hitherto the discoveries amongst the ruins of the city, and the interpretation of the cuneiform inscriptions, have furnished no evidence of any conquest of Assyria by a foreign race corresponding with the statements of the Greek historians and of Josephus, although there is reason to believe from the monuments that a change of dynasty took place about 750 B.C. It may therefore be presumed that the supposed destruction of Nineveh by Arbaces refers rather to a revolt of the Medes, ultimately suppressed, with which it has been confounded, than to a revolution causing the overthrow of the empire and an organic change of government. The whole question is involved in so much obscurity, that it can scarcely be determined by any attempt, however ingenious, to reconcile the conflicting statements of Greek writers. A better acquaintance with the contents of the cuneiform inscriptions can alone afford authentic information upon this subject.

Nineveh

The earliest mention of Nineveh after its fall is to be found in the Greek geographers. Herodotus, B.C. 440, alludes to it, when describing a canal connecting the Euphrates with the Tigris, as having stood upon the banks of this latter river (i. 193); and again mentions it casually in his sketch of Assyrian history. He evidently speaks of it as no longer existing in his day. As he gives so ample a description of Babylon, and as, in his journey thither, he probably descended the Tigris, and must have passed the very site of the sister city, it is to be presumed that he would have left some account even of any ruins that might have

Nineveh. been still standing. The supposition that Nineveh had been entirely destroyed and deserted by its inhabitants long before his time, and had not been rebuilt, is confirmed by the fact, that Xenophon does not even mention the name of Nineveh, although, when leading the Ten Thousand in their memorable retreat through the Assyrian plains forty years later, he actually marched over the ground on which the city once stood; a remarkable circumstance, considering the important part Nineveh had played in the history of Asia. He describes, however, a large uninhabited castle, the walls of which consisted of a plinth 50 feet high, and as many broad, built of polished stones full of shells, and supporting a superstructure of brick masonry of the same breadth, but double the height. He gives no name to these ruins, although they were actually the walls of part of the ancient city of Nineveh, merely observing that they were near a Median town called Mespila, also, it would appear, uninhabited. Some similarity in the name has suggested the identification of this place with Mosul, which stands on the western bank of the Tigris, immediately opposite the remains described by the Greek commander.

Ctesias, who was Xenophon's contemporary, describes the city as one which had never been exceeded in the extent and magnificence of its walls, but makes the strange blunder of placing it on the Euphrates (*Frag.* i. 4), in which he has been followed by Diodorus Siculus (ii. 27, 28), and which can only be accounted for on the supposition, either that the city had completely disappeared, or that an error had crept at a very early period into the original text. A fragment from Ctesias, preserved by Nicolaus Damascenus, restores the city to its true site on the Tigris (K. O. Müller, *Frag. Hist. Græc.* iii. 858).

About seventy years after the retreat of the Ten Thousand, Alexander fought his great battle of Arbela near the village of Gaugamela, almost within sight of the very ruins described by Xenophon; yet none of the historians of his campaigns ever allude to them, or mention the name of Nineveh. Strabo, Diodorus Siculus, Ptolemy, and other writers, only refer to the city as having been the capital of the extinct Assyrian empire, or describe some of its monuments from traditions preserved in earlier records. We may therefore conclude that Nineveh was not only entirely deserted and destroyed after its capture by the Persians and Babylonians, but that no attempt was made to rebuild or re-occupy it. Indeed, its position was not such as to render it important as a centre of trade or traffic. It could only have risen to greatness and wealth as the capital of an empire and the seat of government. When Babylon usurped those honours, a busy population was no longer attracted to Nineveh.

Some centuries later, however, a small fortified town, probably of Parthian origin, seems to have been built on the ruins of the ancient city, and to have been even called by its name. From the numerous Roman and Parthian remains, such as fragments of terra cotta figures and coins, found in the rubbish which had accumulated over the Assyrian ruins, we may suppose that it stood on one of the great mounds opposite Mosul. Ammianus Marcellinus (xxiii. 20) mentions "Nineve," and Tacitus (xii. 3) alludes to the capture of "Ninos" by Meherdates. It became incorporated at one time in the Roman empire; and two Roman coins are known to have been struck there; one of Trajan, with the legend AUG. FELI. NINI. . . . CLAV, the other of Maximinus, with the legend COL. NINIVA. CLAVD. It would seem, from the epithet "Claudiopolis," that the new town had been restored or rebuilt under the Emperor Claudius. (Layard, *Nin. and Bab.* 591.) It appears to have also borne at one time the name of Hierapolis. In a tomb, probably of Parthian origin, found amongst the ruins, was preserved a gold coin of the Emperor Maximinus.

A small village called Ninoua is mentioned both by the Arab geographers and by European travellers as standing on the site of Nineveh in the middle ages. Both village and name have long since disappeared. The tradition of the site of the ancient city is, however, still preserved by the few Christians who live around the ruins, and by the Mohammedans in their peculiar veneration for an edifice supposed, but without any reason whatever, to cover the tomb of Jonah, built over one of the principal buried ruins, and probably upon the foundations of an early Christian church or monastery dedicated to the prophet. The great mound opposite Mosul on which the Roman or Parthian fortress of Ninos is supposed to have stood, is now called by the Turks *Kouyunjik—i.e.*, "The Little Sheep;" by the Arabs, *Armousheeah*. The origin of both names is unknown. Nineveh.

The ruins opposite Mosul have been mentioned by most travellers, ancient and modern, who have visited that town; but the first to give any accurate description and plan of them was Mr Rich, for some years political agent of the East India Company at Baghdad. In the year 1820 he was able to make a careful survey of them, which was subsequently published by his widow. The Arabs in the neighbourhood informed him that some time previous to his visit the figures of men and animals sculptured in stone had been dug out of one of the mounds. They had been immediately destroyed by the Mohammedans as idols belonging to the infidels, and Mr Rich was unable to obtain even a fragment. He only succeeded in collecting a few specimens of pottery and bricks inscribed with cuneiform characters, and one or two Assyrian relics. Ruins similar to those examined by Mr Rich abound in the region watered by the Euphrates and Tigris. They consist of enormous mounds of earth rising abruptly from the plain. At some distance they appear like natural elevations or mere heaps of earth; it is only on closer inspection that they are found to be the work of men's hands. Where the winter rains have worn deep furrows in their sides, may be traced masses of solid masonry, either of bricks baked in the kiln, or simply dried in the sun. On and around them, far and wide, are scattered fragments of pottery, the sure sign of former population. The Arabs not unfrequently choose these artificial elevations as the site of their villages of rude mud huts, either building upon their summit, as a position easy of defence against marauding Bedouins, or at their foot. They call them *Tel*, a name by which they appear to have been known even in the time of the Jewish captivity. The principal mounds of this description on or near the site of Nineveh are those already mentioned near Mosul, usually identified with the remains of the city;—Nimroud, near the junction of the Rivers Tigris and Great Zâb, about 20 miles to the S. of Kouyunjik; Selamiyah, 3 miles to the N. of Nimroud; Khorsabad, 12 miles to the N.E. of Mosul; and Karamles, about 15 miles to the N.E. of Nimroud. The space between these ruins contains numerous smaller mounds covering the remains of ancient edifices; and on all sides may be found the traces of former habitations. The groups of Kouyunjik, Nimroud, Selamiyah, and Khorsabad, are remarkable as each comprising one or more large mounds, and the remains of a regular system of walls and defences inclosing a considerable area. The other ruins are isolated and scattered over the face of the country without apparent order or design.

In the year 1841 M. Botta, who had been recently appointed French consul at Mosul, determined to examine more carefully than had hitherto been attempted the mound of Kouyunjik. For this purpose he employed a party of Arabs to excavate in it, but without other result than the discovery of a few fragments of inscribed slabs. A peasant having informed him that remains of ancient buildings had been found at Khorsabad in digging the foundation of a house, he removed his workmen to that ruin. He was

Nineveh. almost immediately rewarded by the discovery of a series of upright slabs in a coarse grayish alabaster, sculptured in bas-relief, with figures of men and animals, and with inscriptions in the cuneiform or arrow-headed character, then only known from Persian monuments of the Achmenian dynasty, and a few fragments from the ruins of Assyria and Babylonia. These slabs were found to be the panelling of the lower part of a room filled with earth and rubbish. A doorway opened into a second apartment, and further excavations disclosed a series of halls and chambers of different dimensions lined with similar sculptured slabs. After some months' labour, the greater part of the ground plan of a magnificent palace was laid bare.

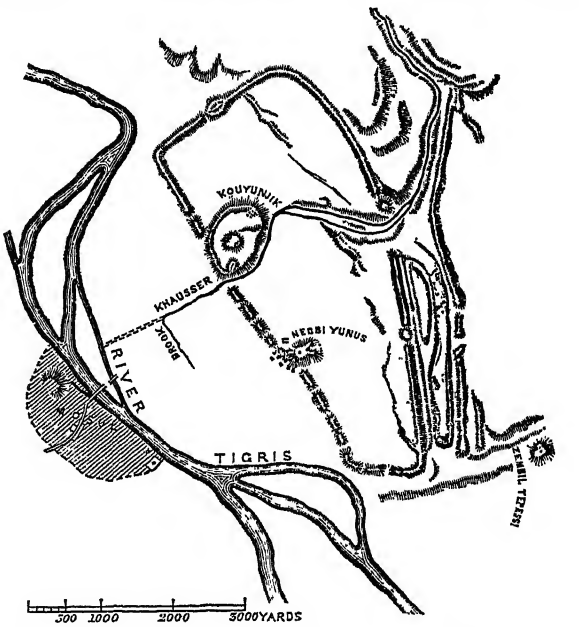
This edifice had evidently been destroyed by fire, which had calcined the alabaster slabs. A mass of charred wood, bricks, and other materials, employed in the construction of the building, completely covered the ruins. Above this heap of rubbish soil had accumulated. The surface of the mound yearly produced a crop of barley or corn, and on one part stood a small Arab village. The huts were purchased, and pulled down. Subsequently, under the directions of M. Place, the ruins of a propylæum and of a broad flight of steps leading up to the building were uncovered.

The principal mound at Khorsabad may be divided into two parts; an upper, about 650 feet square, and 30 feet high; and a lower, connected with it, about 1350 feet by 300. At one corner it is a low pyramidal elevation, which may mark the remains of a watch-tower or the superstructure of a royal tomb. The entire quadrangle, inclosed by walls, would be about 1⅛ mile square. It contains no other ruin of any importance.

M. Botta's discoveries at Khorsabad were followed by those of Mr Layard at Nimroud, where ruins of a similar character, though of greater antiquity and of more importance, as being the remains of buildings of several different epochs, were uncovered. A mound 700 yards by 400, surmounted by a conical elevation or pyramid 140 feet high, forms the corner of a walled inclosure 2331 yards by 2095 in the widest part. The Tigris once flowed under the western face of this quadrangle, and at the foot of the great mound. It is now 1¼ mile distant. The northern wall still shows the remains of fifty-eight nearly equidistant towers; in the eastern only fifty can be traced. A deep ditch or moat appears to have defended such parts of the inclosure as were not protected by the river. The remains of several distinct buildings, erected by different kings, were found in the principal mound. In one instance, materials, such as sculptured slabs, had been taken from one edifice to be used in the erection of another. Some had been destroyed by fire, others appeared to have been suddenly covered by the falling in of the upper stories. In the one case, the sculptures were calcined, as at Khorsabad; in the other, they were perfectly preserved with all their original sharpness and minute details. Many of the chambers were panelled with slabs having nothing but the same inscription repeated over and over again. Others were lined with bas-reliefs singularly interesting and elaborate. The pyramid was found to be the remains of a square edifice, solidly constructed of sun-dried bricks, faced to the height of 20 feet with masonry of large stones carefully squared and bevelled, and above that height with kiln-burned bricks. In the interior was discovered one vaulted gallery 100 feet long, 12 high, and only 6 broad. It was probably a royal sepulchre, but had been despoiled at some remote period of its contents. It has been conjectured that it may represent the tomb of Sardanapalus, which the Greeks described as placed at one of the entrances to the city. No remains of modern habitations existed in any part of the ruins. A small Arab village, named after them, has been built about one mile from the great mound.

Excavations were also carried on by Mr Layard in the ruins opposite Mosul, which consist of two principal mounds, Kouyunjik, and that of Nebbi Yunus (or the tomb of the prophet Jonah). On the sides and at the foot of the latter, facing the river, is an Arab village, and the summit is covered with the graves of Mohammedans who have been buried around the holy edifice. A village formerly stood on Kouyunjik, but its inhabitants deserted it many years ago, and established themselves in the plain beneath. The two mounds form part of the western or river side of the fortified inclosure. Kouyunjik, the largest, measures about 866 yards by 500; Nebbi Yunus, 566 by 400. They are connected by the remains of part of the wall forming the western face of the quadrangle, which is 4530 yards in entire length. The northern wall is 2330 yards; the eastern, which forms a considerable curve, is about 5300; whilst the southern is scarcely 1000; the inclosure having thus the form of an irregular quadrangle, approaching to a trapezium. The northern face was defended by a deep

Nineveh.



moat; the western was protected by the Tigris, which washed the walls, but has long since deserted its ancient bed, and now flows about three-fourths of a mile from Kouyunjik; still, however, approaching the north-west corner of the inclosure. On the southern face was a ditch and an exterior rampart. The eastern face, being the most exposed, was the most strongly fortified. For this purpose the nature of the ground offered many advantages. The Khausser, a deep, sluggish stream, divides the quadrangle into two nearly equal parts, and winds round the base of Kouyunjik. Before entering the quadrangle, it runs for about 1¼ mile parallel to and near the wall, thus furnishing a strong natural defence. A low ridge of conglomerate rock beyond the Khausser was heightened, by artificial means, to form strong outer ramparts. The fortifications to the south of the point where the Khausser enters the inclosure were very extensive and complete. Two deep and broad ditches, fed by that stream, one dividing itself into two branches, and the outer and larger moat being no less than about 200 feet in width, were separated by a second wall or rampart; whilst a third, still in some places about 100 feet high, faced the open country, and extended almost the entire length of the quadrangle. This outer wall was probably that described by Diodorus Siculus as 100 feet high, and sufficiently wide for three chariots to drive abreast upon it. Its length he absurdly exaggerated. It appears to have been constructed chiefly of the earth and rubbish

Nineveh. removed to form the ditch. No remains of stone facings have been found. The inner wall was built of stone and brick masonry. It no doubt resembled those of the fortified cities represented in the Assyrian bas-reliefs, with towers at equal distances (many may still be traced), and surmounted by ornamental battlements of stone, portions of which have been found among the ruins. The entrances or gateways were probably arched; two have been discovered and partly excavated, one nearly in the centre of the northern, the other in the inner eastern wall. The former consisted of two halls, 70 feet by 23, opening upon the plain, and upon the interior of the inclosure by gateways flanked by colossal man-headed bulls and winged human figures. On the pavement of limestone slabs could still be traced the ruts of the chariot wheels. From the immense mass of bricks, charred wood, and rubbish in which this gateway was buried, it may be conjectured that a lofty tower rose above it, which, like the palace, was destroyed by fire.

The ruins of the palace at Kouyunjik are similar to those at Nimroud and Khorsabad, but belong to an edifice of greater extent and magnificence than either. The dimensions of the principal courts or halls exceed those of any other Assyrian building yet discovered. Every part of the palace was adorned with sculptures. During the excavations carried on by Mr Layard no less than 71 chambers, panelled with nearly two miles of bas-reliefs, and 27 entrances formed by colossal winged bulls or lion sphinxes, were uncovered, and scarcely half the palace was examined. Works since carried on under the superintendence of Mr Hormuzd Rassam and of Mr Loftus have brought to light a large number of additional apartments.

The sanctity attached by the Mohammedans of Mosul to the tomb of Jonah, has prevented Europeans from exploring to any extent the mound upon which it stands. Remains of building resembling those at Kouyunjik, and of nearly the same period, were, however, discovered in it by Mr Layard; and subsequent excavations on a small scale, undertaken by the Turkish government, have proved the existence of a palace adorned with sculptures and sphinxes.

The ruins of a palace or temple have also been discovered in the mound of Shereef-Khan, about 5½ miles to the north of Kouyunjik; and nearly all the mounds scattered over the plain between the Tigris and the hills have, when examined, been found to contain remains of edifices, but none have furnished sculptured or inscribed slabs. The principal ruins in the district are,—Selamiyah, three miles north of Nimroud, with a walled inclosure about three miles in circuit; Karamles (near the field of the battle of Gaugamela or Arbela); Baashiekha; and Baazani.

The most ancient Assyrian edifice hitherto discovered is that at the north-western corner of the mound of Nimroud. It appears to have been rebuilt, if not founded, by a king whose name is believed, by some interpreters of the cuneiform character, to read Asshur-dan-pal, and to correspond with the Greek Sardanapalus. The approximate date of his reign may be from 950 to 920 B.C. His son, whose name is read Shalmanee-bar, erected a second palace in the centre of the same mound. His grandson (? Phallukha), who is identified with the Scriptural Pul, and whose queen is supposed to have been the celebrated Semiramis, her name having been found on monuments from this building, rebuilt this edifice, and founded a third near the spot.

The next palace in order of date is that at Khorsabad, raised by a king who has been identified with the Sargon of Isaiah (xx.), and who would have consequently reigned about 725 B.C. The ruins of this building were called, after him, Saràoun even long after the Arab conquest. The great palace excavated at Kouyunjik was founded by Sennacherib about 700 B.C., as well as those at Shereef-Khan and at Nebbi-Yunus, the latter of which appears to have been finished by his son Essarhaddon, who added an additional edifice to the group already erected at Nimroud, and for this purpose appears to have destroyed, or taken materials from, those built by Sardanapalus, by the Tiglath-pileser of Scripture, and others, his predecessors. The son of Essarhaddon, whose name also has some resemblance to Sardanapalus, completed or enlarged the palace of his grandfather at Kouyunjik, and added to that at Shereef-Khan. Remains of an edifice belonging to his son, rudely constructed, and without the usual ornamental sculptures, were discovered in the south-east corner of the mound of Nimroud. Nineveh.

It is possible that all these palaces may have been built upon the sites of more ancient edifices, of which, however, no traces have hitherto been found. There can be little doubt that Nineveh was founded several centuries previous to the erection of the earliest buildings as yet uncovered. If any value is to be attached to the dynastic lists of Ctesias and other Greek writers, which are, however, rejected as entirely untrustworthy by the interpreters of the cuneiform inscriptions, the city must have existed nearly twenty-two centuries B.C.; and this conjecture is strengthened by its agreement with biblical chronology. The name of Nineveh occurs more than once on Egyptian monuments of Thothmes III., or fourteen centuries B.C. Kings who occupied the throne long previous to the first Sardanapalus, the builder of the north-west palace at Nimroud, are mentioned in the inscriptions; but although Nineveh appears to have been a flourishing city even under those monarchs, the capital of the empire, according to Sir Henry Rawlinson, was some 60 miles lower down the Tigris, on the western bank, and is marked by the ruins of Kalah-Sherghat, where monuments of a highly interesting character have been discovered. The first of these kings may have reigned about twelve centuries B.C., but there is reason to believe that events of Assyrian history are alluded to on monuments of a much earlier date. According to the inscriptions it would seem that Sennacherib was the first to move the seat of government to Nineveh, which he almost entirely rebuilt, the city having fallen into decay and ruin. But it must be observed, with reference to all conjectures founded upon the interpretation of the cuneiform characters, that our present knowledge of the ancient writing and language of Assyria is far too uncertain to admit of any positive conclusions. The dates of the earlier edifices at Nineveh depend entirely upon the correct rendering of the inscriptions. We know that the ruins of the north-west palace at Nimroud are the most ancient yet discovered, and the traditions still existing in the country point to them as such; but as yet we have no positive evidence to identify its founder with any monarch mentioned in history, or the date of whose reign can be established by any proof.[1] On the other hand, there is much concurrent evidence of a very remarkable character, besides the interpretation of the names on the monuments themselves, to enable us to assign the palaces of Khorsabad, and Kouyunjik to Sargon and Sennacherib. On monuments of the latter monarch have been discovered inscriptions of extraordinary interest, containing the name of Hezekiah, and a record of the invasion of Judea and siege of Lachish, mentioned in the book of Kings.

[1] On the black obelisk (now in the British Museum) raised by the son of the founder of the north-west palace, mention is believed to be made of Jehu, the son of Omri, "Yahua, the son of Kumri," and of Samaria as "Beth-Kumri," (the House of Omri); and on monuments from the same edifice, Benhadad, King of Damascus (1 Kings xx.) is supposed to be included in the list of kings who paid tribute to Assyria. In an inscription of a later monarch, ascertained to be the Scriptural Pul, "Menahem, King of Samaria, and Hiram, King of Tyre," are spoken of.

Nineveh. Such being the ruins on or near the site of Nineveh, and their relative antiquity, it remains to be determined which represent the ancient city. It is evident that the space inclosed within the quadrangle opposite Mosul could not have contained a capital of such vast extent and importance as is assigned to Nineveh by the concurrent testimony of sacred and profane writers. The description in the book of Jonah is too vague and obscure to convey any definite idea of its size. Do the three days' journey imply the circuit of the city, its extreme length, or the time employed in traversing its principal streets? Are the "six score thousand persons who did not know their right hand from their left" intended to comprise a particular class, such as children; or is the expression used to mark the general ignorance of the whole population? In the one case, the city would have been of enormous extent, and would have contained about 600,000 inhabitants; in the other, it would have been of moderate size, with a population of 120,000. The dimensions assigned to Nineveh by the Greek geographers are more definite; and although in many respects undoubtedly fabulous, curiously confirm those given in the book of Jonah. Diodorus Siculus, who derived his information chiefly, it would appear, from Ctesias, states that the city formed a quadrangle 150 stadia by 90, the square being thus 480 stadia, or about 60 miles, corresponding to the three days' journey of Jonah. Strabo declares that Nineveh was larger than Babylon, the circuit of whose walls were, according to him, 385 stadia; and according to Herodotus 480. The inclosure of Kouyunjik being scarcely 9 miles in circuit, including even the outer ramparts, cannot be that described by Diodorus; but as an instance of the inaccuracy of Greek writers in giving such dimensions, or of errors that may have crept into the text of their works, we find this very quadrangle opposite Mosul stated by Xenophon, after actual personal observation, to be six parasangs, or about 18 miles in circuit, just double its actual extent.[1]

To reconcile all conflicting statements, it has been conjectured that Kouyunjik, Khorsabad, Nimroud, and Karamles, with the numerous ruins in the intervening plain, may represent altogether the site of Nineveh. The careful surveys of Captain Felix Jones of the East India Company's navy (published by the East India Company), prove that these mounds occupy the four corners of a square, inclosing an area agreeing very nearly with that assigned to the city by Diodorus. It is assumed that each of these four groups was a fortified quarter of the city, a place of refuge and defence, including the palace of the king and his attendants, the temples and the dwelling-places of those attached to them, and the royal park or paradise. The space between them is assumed to have been occupied by the habitations of the people at large, scattered far and wide over the face of the country, and not collected together, as in a European city, by gardens and by cultivated fields. This is not inconsistent with Eastern habits. Ispahan and Damascus, with their suburbs, are cities of this kind. Within the precincts of Babylon, according to Diodorus Siculus and Quintus Curtius, corn could be raised sufficient for the sustenance of the whole population, in the event of a siege.

On the other hand, if the inscriptions be correctly deciphered, the inclosure opposite Mosul was alone called Nineveh; Khorsabad and other mounds around having distinct names. Nimroud (the *Larissa* of Xenophon) Sir H. Rawlinson would identify with Calah, mentioned in the 10th chapter of Genesis. But then no ruins, except Selamiyah, which are not of sufficient extent or importance, would mark the site of Resen, "a great city between Nineveh and Calah." He assumes that all the ruins described represent separate and distinct cities, which were, however, in the time of the prophet Jonah, known altogether by the common name of Nineveh. It is quite clear that, whatever may have been the extent of the city, there were no walls corresponding in extent with the description of Diodorus. If such ever existed, it is impossible that no traces of them should be found. Nineveh.

There are no remains to show the general plan of the city or of its principal quarters, the form of its streets, or the nature of the common dwelling-places of its inhabitants. It probably consisted, like most modern Eastern cities, of a few great edifices devoted to royal or sacred purposes, and constructed of rich and valuable materials; the abodes of the people being of the meanest and rudest description. Bricks made of clay, mixed with chopped straw, and simply dried in the sun, were generally used for building, as they still are in Assyria. Houses so built, when once abandoned, soon fell into complete decay; and their ruins, exposed to the winter rains and the summer's sun, soon crumbled to dust. A modern Arab village, when once deserted, disappears in a few years, leaving scarcely a trace behind. Masonry of sun-dried bricks, when properly protected, and when buried, as in the Assyrian mounds, defies the ravages of time. The walls of the palaces of Nineveh in this material are in many places still as perfect as when first raised.

The great public edifices have alone been sufficiently well preserved to furnish any idea of the style of architecture presented at Nineveh. Assyrian architecture appears to have originated on the banks of the Tigris and Euphrates. It owes its distinctive features to the fact of the first great public edifices of the race which devised it having been erected upon the plains of Assyria and Babylonia. In order to raise the building, for the sake of dignity or defence, high above the surrounding country, it was necessary to form an artificial elevation, and those enormous platforms or mounds were constructed which form one of the chief characteristics of Assyrian and Babylonian ruins. This substructure was either of solid masonry of sun-dried bricks, or simply of earth and rubbish heaped up. In the bas-reliefs from Kouyunjik is represented the process of building it. Long lines of workmen, many of them prisoners or slaves, chained together and in fetters, are seen emptying baskets filled with earth and stones on the accumulating heap. The substructure was raised about 40 or 50 feet above the level of the plain, and was generally faced with masonry or stone. Broad flights of steps led up to the summit. The public edifice or palace was constructed principally of sun-dried bricks, but parts of the building required more solid and more costly materials. To supply the first, the kiln-burnt bricks were used; for ornament, the Ninevites employed a coarse grayish alabaster found in abundance in the immediate vicinity of their city. A remarkable feature in these buildings was the immense thickness of the walls, rarely less than 10 feet, generally about 15 feet. They were built of sun-dried bricks, and panelled with upright sculptured alabaster slabs, from 8 to 10 feet high, 3 to 4 feet broad, and about 18 inches thick, placed close to one another, but not united by any mortar or cement. Above these slabs the wall was either faced with kiln-burnt bricks, plain or coated with enamel, forming elegant designs and patterns of the most brilliant colours, or plastered and painted. Cedar and other precious woods, gilding, ivory, and bronze, were also used to decorate the sides of the chambers. These materials appear to be mentioned in the inscriptions as having been brought from afar; cedar-wood, for instance, from Mount Lebanon. The ceil-

[1] The length of Xenophon's parasang may be determined by reference to the distances assigned to the marches of the Ten Thousand in their retreat.

Nineveh.

ings of the rooms were also probably of cedar. Large quantities of this precious wood were found in the ruins of Nimroud. There is reason to believe that many of the chambers were vaulted. Discoveries in the ruins prove that the Assyrians were well acquainted with the principle of the arch, and employed it in forming these entrances. The principal doorways, and generally all those leading into the great halls or courts, were flanked by those well-known emblematic figures, now characteristic of Assyrian architecture, uniting the body of a lion or a bull with the head of a man and the wings of an eagle. These were usually of gigantic proportions, and on these were generally inscribed the annals of the reign of the king who caused them to be erected.

The alabaster slabs placed against the walls were sculptured in bas-relief, or had an inscription carved upon them. The sculptures were of two kinds—either figures of priests or divinities of colossal size, or subjects representing battles, sieges, hunting scenes, sacrifices, &c. In the latter case, the slab was divided into two parts by an inscription running across in a horizontal band, and containing a description of the work portrayed above or beneath. Remains of colour upon the bas-reliefs prove that they were originally painted. The pavement of the chambers consisted of alabaster slabs, either carved with rich and elegant pictures, or covered with inscriptions, or more usually of large square kiln-burnt bricks. On the back of almost every slab or stone used in the building was carved the name of the king who founded it, together with a short inscription containing his titles, the names of the principal gods, and the countries he ruled over. Upon the kiln-burnt bricks also was generally stamped or inscribed the name of the king. The interior of these magnificent edifices was adorned with statues of the gods and of the king, and with obelisks and stelæ of marble and other materials covered with bas-reliefs and inscriptions recording the conquest and other remarkable events of the reigns of Assyrian monarchs. Several of these monuments discovered in the ruins are now in the British Museum.

These vast edifices were probably at the same time the palace and the temple, the residence of him who was both the high priest and the political chief of the nation. These offices were at one time similarly united in Egypt, and the palace-temple was the dwelling-place of the king. Parts of the building may have been specially set apart for worship and dedicated to a particular god; but no detached temple, as in ancient Greece, has been as yet found on the site of Nineveh. The inscriptions, however, appear to mention the fact of temples of extraordinary magnificence, adorned with silver and gold, having been raised in different parts of the empire. The palace was also the house of records of the nation; on its walls were pictured and described its triumphs, and the prowess of its monarch in war and in the chase.

The palaces of Nineveh seem to have been constructed upon one general plan, and consisted of a number of chambers of various sizes grouped round large central halls, which were probably open to the sky, and resembled the courts of modern Persian houses. No columns of any kind, nor pedestals for pillars of wood for supporting a roof, have been discovered. Pillars of wood brought from distant countries appear to be mentioned in the inscriptions, and columns are frequently represented in the bas-reliefs. No traces of windows have been found in the walls; consequently, it may be presumed that the rooms were either lighted from above or through the doors only. The latter may have been the case, as in modern houses at Baghdad and Mosul, in which, for the sake of coolness, the apartments are kept as dark as possible. From the immense heap of bricks, earth, and rubbish covering every part of the ruins, and filling every chamber, frequently rising as much as 15 or 20 feet above the level of the sculptured slabs, as well as from the representations of buildings seen in the bas-reliefs, it is probable that these palaces consisted of more than one storey, and that the upper part having fallen in, completely buried the lower. The admirable preservation of the greater part of the sculptures, although executed in a very soft material, which would have perished from even short exposure, proves that such must have been the case, and that the entire destruction of the buildings must have been very sudden.

Ning-po.

No remains of the outer walls of an Assyrian palace, hitherto discovered, are sufficient to furnish an accurate idea of the exterior architecture of Nineveh. Only the lower part of a façade at Kouyunjik has yet been excavated. It consists of three grand entrances formed by groups of colossal winged bulls and human figures, some flanking the doorways, others placed back to back, and facing outwards. From what still remains, and by comparison with ancient buildings in other parts of the East, principally in Persia, Mr Fergusson (*Palaces of Nineveh and Persepolis Restored*) has with great ingenuity endeavoured to restore a Ninevite palace. The discoveries at Kouyunjik of bas-reliefs supposed to represent an Assyrian edifice go far to verify his conjectures. There is nearly the same arrangement of columns in an upper storey resting upon a solid basement. The capitals are ornamented with volutes resembling those of the Ionic order, and they rest upon the backs of winged bulls and sphinxes. The Persians appear to have derived both their religion and their architecture from the Assyrians. The latter was somewhat modified by locality, and by the vicinity of quarries of fine building-stone; but the palaces of Xerxes and Darius at Persepolis were erected upon nearly the same plan, and were adorned with nearly the same ornaments and the same typical figures, as those at Nineveh. Being built chiefly of stone, they have defied for a longer period, although exposed to the air, the ravages of time. One of the most remarkable facts connected with the discovery of the ruins of the palaces of Nineveh is, the proof which they afford that the Greeks derived their Ionic order of architecture from Assyria. It reached them through Asia Minor and Ionia. Not only was the Ionic volute the ordinary termination to an Assyrian column, but the usual ornaments found on Ionic monuments in Greece are for the most part purely Assyrian. According to the interpretation of the inscriptions, the kings of Assyria shortly before the fall of the empire employed Greek and Phœnician artists in decorating their palaces, and records have been found of the names of the kings who sent them and the cities from whence they came.

Another important result of the discoveries at Nineveh is, that they enable us to understand the architectural descriptions contained in the Bible, and especially those relating to the palaces and temples erected by Solomon, to which, both in the general plan, the materials employed, and the style of the ornaments, they appear to have borne a very close resemblance. The Jewish edifices were, however, far inferior in size to those of Assyria.

According to a tradition preserved by Greek authors, Nineveh was finally captured by the Persians and Babylonians through a breach in its walls caused by a sudden overflow of the waters of the Tigris. There are no indications of this event either in the ruins of Kouyunjik or of Nimroud. All the edifices hitherto discovered, except the north-west palace, attributed to Sardanapalus, show undoubted marks of having been destroyed by fire, and many conclude that the city was at last overwhelmed, never to rise again, by one mighty conflagration. (A. H. L.)

NING-PO, an important city of China, one of the five seaports open to foreign trade, and the principal emporium in the province of Che-Keang, stands in a fine plain on the

Ninian ‖ Ninians, St.

left bank of the Takia, Lat. 29. 51. N.; Long. 121. 32. E. It is surrounded by walls, having a circumference of 5 miles, a height of 25 feet, a breadth of 22 feet at the base and 15 at the summit; and is entered by five gates. The walls are in a state of considerable dilapidation, and there are large suburbs on the outside. Although considered by the Chinese as one of the finest cities in the empire, Ning-po does not strike Europeans as at all remarkable for its elegance; the streets being very narrow and dirty, and the houses, built for the most part of brick, rarely exceeding one storey in height. It is intersected by several canals, and the river is crossed by a floating bridge. Among the principal buildings are a hexagonal brick tower of seven storeys, 160 feet high, and said to be upwards of 1000 years old; numerous pagodas and public offices; as well as the temple of *Ma Tsupu*. Near the margin of the river there are numerous shops and storehouses, which excel in wealth and splendour those of Canton; and near the city gates there are many eating-houses and tea-shops. A missionary hospital, which was founded here in 1843, is of great public utility, and is used not only by the poorer classes, for whom it was specially intended, but by all ranks of society. Manufactures of silk are carried on here, as at Canton; cotton stuffs, carpets, furniture, &c., are also produced; and in the vicinity are large salt-works. The building of junks is also carried on to a considerable extent. The trade of the place is very considerable, as it is the principal port intermediate between the northern and southern provinces; and owing to the superior speed and safety of British vessels, the coasting seems to be rapidly passing out of the hands of the Chinese. The number of British vessels that entered and cleared here in 1856 was 206; tonnage, 26,004. British goods are only imported to a small extent; but large quantities of the produce of Singapore and the Straits of Malacca find a market here. Among the exports to Great Britain in 1856 was green tea to the value of L.4328; and the principal other articles of export are raw and manufactured goods of native produce, for the use of the Chinese on the coasts and in the British colonies. The trade of the port is on the whole in a flourishing and increasing condition. Pop. estimated at between 200,000 and 300,000.

NINIAN, or NINYAS, commonly called *St Ninian*, and sometimes *St Ringan*, a distinguished bishop among the ancient Britons, and said to be the first who carried the light of Christianity into Scotland, seems to have been a Briton of noble birth and excellent genius. After receiving a tolerable education at home, he visited Rome in A.D. 370, where he spent several years in study. On his return to Britain he engaged with great zeal and success in preaching the gospel in the most uncultivated parts of the island. He chose the modern Whitehorn in Wigtownshire as the centre of his operations (called by Ptolemy, ii. 3, Λευκοπιβία; and by the Romans, who had a station there, *Candida Casa*), then one of the two towns of the Novantæ (the Νοουανται of Ptolemy), who inhabited *Gallovidia* (Galloway). We learn from Bede (*Hist. Eccles.*, lib. iii.), that Ninian built a fine church there about A.D. 400, which he dedicated to St Martin; and owing to his great success as a Christian missionary was afterwards made bishop of Whitehorn. This place was the centre of Christian light in Scotland for more than a hundred years before the arrival of Columba. Some of the ruins of St Ninian's church are still shown at Whitehorn; and various localities in Scotland still bear traces of the name and the reputation of this zealous missionary.

NINIAN'S, ST, a village and parish of Scotland, in the county of Stirling, about 1 mile S. of the town of Stirling. It consists of one main street of old whitewashed houses; and has a parish, a Free, and a United Presbyterian church; and several schools. Malt, whisky, leather, carpets, tartans, nails, &c., are manufactured here. Pop. of the parish (1851) 9851.

Ninove ‖ Nipissing.

NINOVE, a town of Belgium, in the province of East Flanders, on the left bank of the Dendre, 20 miles S.E. of Ghent. It contains several churches and schools, a town-hall, and an hospital. There are breweries, dyeworks, bleachfields, brick-kilns, and manufactories of earthenware, leather, soap, tobacco, vinegar, thread, linen and woollen fabrics, &c. Some trade is carried on in wool, grain, cattle, and manufactured articles. Pop. 4718.

NIOBE, the daughter of Tantalus, King of Lydia. The incidents in her life are related differently by different authors; but the following is the simple legend given by Homer:—She was married to Amphion, King of Thebes, and bore to her husband six sons and six daughters. Proud of the number of her children, she began to assert a scornful superiority over Latona, who was a less happy wife. Hereupon Apollo and Diana, enraged at the insult cast upon their mother, bent their bows, and slew the sons and daughters of the doting Niobe. The childless queen, in her distracted sorrow, found her way eastward to her father's kingdom. As she stood one day on Mount Sipylus, in the motionless attitude of mute despair, she was changed by the commiserating Jupiter into stone. There for many ages afterwards the simple-minded believer of legends could still detect in the rough outline of a crag the weeping figure of the unhappy Niobe. This story was the subject of several ancient sculptures. One of these, a group of fourteen statues, representing the mother in the midst of her dying children, was dug up at Rome at some date before 1583, and was conveyed to Florence in 1775. It now stands in the Uffizi gallery of the latter city, exciting by its grandeur the admiration of connoisseurs. (See ARTS, *Fine*.) Various conjectures have been made regarding the authorship and the original position of these statues. Winckelmann supposed that they were the work of Scopas; and the English architect Cockerell has shown that they were probably arranged on the tympanum of a temple.

NIORT, a town of France, capital of the department of Deux-Sèvres, stands in the midst of a rich and beautiful region, on the slopes of two hills, separated by the Sèvre-Niortaise, 79 miles S.E. of Nantes, and 225 S.W. of Paris. It was formerly very meanly built; but has recently been much improved, and has now many handsome streets and two fine public squares. There are two churches, one of which is an ancient Gothic building with a lofty spire; a town-hall, formerly the palace of Eleanor of Guienne, queen of Henry II. of England; an old castle now used as a prison, in which Madame de Maintenon was born; a prefecture, a theatre, public library, baths, cavalry barracks, civil and military hospitals, &c. Niort is the seat of courts of primary jurisdiction and of commerce, of a council of *prud'hommes*, an agricultural society, and a commercial college. The principal manufactures are leather and gloves, especially of doeskin, of which not less than 30,000 dozen are annually made. Shoes, woollen and cotton yarn, saddles, paper, saltpetre, articles of wood and horn, &c., are also produced here. The commerce of the place is considerable in wine, corn, flour, wool, timber, manufactured goods, &c. The Sèvre is navigable as far as Niort. Pop. (1856) 18,136.

NIPHON. See JAPAN.

NIPISSING, LAKE, a lake of Upper Canada, lying midway between the Ottawa or Grand River and Georgian Bay, an inlet of Lake Huron. Its form is irregular; its length is about 48 miles, its greatest breadth 25, and its altitude 750 feet above the sea. Its principal affluent is the Sturgeon River from the N., which connects it with other lakes; and it discharges its waters by the French River into Lake Huron. The lake contains several islands, occupied by Indians; and abounds in large flocks of geese.

Nisan ‖ Nismes.

NISAN, the first month of the Hebrew civil year. (See ABIB.)

NISHAPOOR, a town of Persia, province of Khorassan, the capital of a district of its own name, stands in a beautiful valley, 46 miles W. by S. of Meshed. It is meanly built, for the most part of mud, and many of the houses are in ruins. A wall and ditch, with a circumference of about 4000 paces, surround the town, in which the only public buildings are an unsightly mosque and a pretty large and well-filled bazaar. About 40 miles W.N.W. of Nishapoor there are eight or nine mines of very fine turquoises, from which our supply of these stones is chiefly derived; but most of them are very ill worked, and some have been entirely abandoned; so that their produce it much less than it might be under proper management. The town is said to be very ancient, and to have existed in the time of Alexander the Great, by whom it was destroyed. Under the Seljuk dynasty it was one of the four royal cities of Khorassan. In 1269 it was sacked by the Tartars; again by Jhengiz-khan; and, in 1749, by Nadir Shah; from which last calamity it has never recovered. Pop. estimated at 8000.

NISI PRIUS, a legal phrase derived from an ancient writ in which the words occur. Previously to the statute of Westminster 2, trials by assizes or juries could only take place where the king happened to reside, or before the justices on their septennial circuit through the English counties; but by 13th Edw. I., cap. 30, the judges were directed to hold certain assizes in every county not oftener than three times in every year. The statute required that the day and place in the county in which a case was to be tried should be specified in the writ which assembled the jury. Instead, accordingly, of the old writ, commanding the sheriff to bring the jury to Westminster to try the cause, a *nisi prius* clause was added to the writ as follows:—"We command you, that you cause to come before our justices at Westminster, on the morrow of All Souls, twelve lawful men, who, &c., unless before (*nisi prius*) that day A. B. and C. D., our justices assigned for that purpose, shall come to your county to take the assizes there." The day of summons to Westminster is always arranged to be later than the day for taking the county assize, and hence the cause is always tried before the date at which the sheriff is commanded to return the jury to Westminster. In time, the phrase *nisi prius* came to be applied to a large class of judicial business transacted at the several assizes throughout the country before judges of the superior courts. Judges of assize are called judges of *nisi prius;* they are said to be sitting at *nisi prius*, when sitting alone to try causes, and the law by which their decisions are regulated is called the law of *nisi prius*.

NISMES, or NÎMES (anc. *Nemausus*), a town of France, capital of the department of Gard, stands in a wide and fertile plain, between the Rivers Gard on the N., and Vistre on the S., 23 miles W.S.W. of Avignon, 30 N.E. of Montpellier, and 62 N.W. of Marseilles. The older part of the town is surrounded by boulevards, on the site of the fortifications by which it was once defended; and contains narrow and irregular streets lined with old and ill-built houses. The boulevards form fine broad streets, with handsome houses, and are planted with trees; while the outer parts of the town, which comprise about three-fourths of its whole extent, have wide and regular streets, and handsome modern edifices. The line of the Roman walls of Nismes may still be traced; and some parts of them, and two of the gates, are in good preservation. The principal public buildings of the town are those of Roman origin. Of these the largest is the amphitheatre, an oval structure, which now stands, since the adjoining buildings have been cleared away, in the middle of a large open space; it is 437 feet long, 332 broad, and 70 high. The exterior is very well preserved, though the building was used as a fortress in the middle ages. It has two storeys, each consisting of sixty arches. Within these arches, on each storey, a corridor runs entirely round the building; that in the upper storey being smaller than the lower. Access is gained to the interior by four entrances facing the four points of the compass; and from these wedge-shaped passages lead to the centre, and stairs to the upper seats. On the exterior are also to be observed the holes in which the poles were inserted for supporting the awning which shaded the spectators from the heat of the sun. The interior is not so well preserved; but some of the ancient seats, of which there were thirty-two rows, are still to be seen. It is believed that this amphitheatre could contain upwards of 17,000 spectators. Parts of the interior have been restored, but rather clumsily, by a modern architect; and it is still used by the people of Nismes for bull-baiting and other favourite exhibitions. The date of the building is unknown. Antoninus Pius, Titus, and Adrian, have been each conjectured to have been its founder. Another fine building of Roman construction is a Corinthian temple, commonly called the *Maison Carrée*, which is adorned with thirty elegant Corinthian columns. It seems to have originally stood in the market-place of Nemausus, which was inclosed by a colonnade. It has been employed at different times as a heathen temple, a Christian church, a town-hall, a stable, a burial-place, a court-house, a corn warehouse, and a museum; in the last of which capacities it still remains, and contains some antique remains and pictures. A temple of Diana, or, according to some, of the Nymphs; a reservoir, forming the termination of an aqueduct; and a curious octagonal tower, called *La Tourmagne*, whose origin is unknown,—are the chief other ancient buildings in Nismes. Besides these, the town has a cathedral, built in the eleventh century, but considerably altered in subsequent times; several elegant churches; an episcopal palace and seminary; a college, public library, court of justice, barracks, hospital, theatre, &c. Nismes is also the seat of an appeal court for the departments of Gard, Lozère, and Vaucluse; of courts of primary resort and of commerce; a school of design; agricultural and medical societies, &c. As a manufacturing town it holds a high rank; and in the produce of silk it is among the most important places in France. There are several large establishments for dyeing and for printing silk stuffs; but the weaving, which employs from 7000 to 8000 looms in Nismes, is principally carried on by the workmen at their own houses, and not in factories. The silks of Nismes are generally imitations of those of Lyons, and of inferior quality; they are principally used by the lower classes. Tanneries, distilleries, vinegar-works, and potteries, are among the chief manufactories of the place; and in addition to the articles already mentioned, cotton handkerchiefs, hosiery, velvet, chintzes, &c., are extensively produced. An active trade is carried on, especially in raw silk, for which it is the principal emporium in the south of France; and in wine, vinegar, spices, drugs, &c. The importance of Nismes has been recently increased by the construction of railways diverging from this town to Montpellier, Alais, Avignon, Arles, and Marseilles. (Its ancient history is given under NEMAUSUS.) After the fall of the Roman empire it fell into the hands of the Visigoths, who were dispossessed in the beginning of the eighth century by the Moors. The latter were expelled from Nismes by Charles Martel, on which occasion the amphitheatre was partially destroyed by fire, and the town much injured. At the Reformation the greater part of the inhabitants embraced the Protestant religion, and were in consequence subjected to great persecution and cruelty. About one-third of the population are still Protestants, and these form the most wealthy classes in the town. The greatest religious animosity is still kept up between the two sects; and

Nismes.

in 1815 a renewed outburst of intolerance on the part of the Roman Catholics took place. In more peaceful times the mutual aversion of the two parties is shown by the way in which they keep aloof from one another, even frequenting different places of amusement. Nismes was the birth-place of Nicot, who introduced tobacco into France; and of Guizot the historian. Pop. (1856) 49,291.

NISSA, or NISCH, a town of European Turkey, in the province of Servia, stands in a fertile and well-cultivated plain, between two branches of the Balkan Mountains, 60 miles S.S.W. of Widdin, and 130 S.E. of Belgrade. It is separated into two parts by the River Nissava, an affluent of the Morava. The division on the right side, occupied by Turks, is surrounded by good fortifications and a dry ditch; while on the other side is a bazaar, defended by a trench and palisade; and beyond this is the unprotected Christian quarter. The fortifications are mounted with numerous large guns; and Nissa commands the communication between the provinces of Servia, Bulgaria, and Roumelia. The principal building is the palace of the pasha. This place was anciently called *Naissus;* and is remarkable as the birth-place of the Emperor Constantine. It was taken by Amurath II. in 1389, and again by the Austrians in 1737. Pop. 10,000.

NITH, a river of Scotland, rises on the confines of Ayrshire, Kirkcudbrightshire, and Dumfriesshire, flows S.E. through Dumfriesshire, and falls into the Solway Firth after a course of 45 miles. The principal towns on its banks are New Cumnock and Dumfries, the latter about 8 miles from its mouth. The Nith has salmon fisheries of considerable value. It has been rendered a classic stream by the poetry of Burns, who resided for some time at the farm of Ellisland, near Dumfries.

NITHARD, an old French historian, was the son of the famous Abbot Angilbert, and of Bertha, the daughter of Charlemagne, and was born at some date before 790. Succeeding his father as duke or count of the maritime coast, he seems to have risen to an influential position at court. After the death of his uncle Louis Le Débonnaire in 840, his services were employed to effect a reconciliation between the three sons of that monarch; but he was unsuccessful in his negotiations, and it was soon his duty to record the war which broke out between the brother princes. His death took place in 858 or 859, in consequence of a wound which he received in repelling an invasion of the Normans. The history of Nithard is inserted in Duchesne's *Historiæ Francorum Scriptores*, in 5 vols. fol., Paris, 1636–41–49. A French translation has recently appeared in the *Collections des Mémoires Relatifs à l'Histoire de France*, of Guizot.

NITI, a celebrated pass over the Himalaya Mountains, so called from a village of the same name in the vicinity, in the British district of Kumaon, in the North-West Provinces. The ascent from the southern side is for a great part of the way very steep, over rocks of blue limestone; and on the other side it leads to the valley of the Sutlej, which is here 14,924 feet above the sea-level. The height of the crest of the pass is 16,814 feet above the sea. At this great elevation the rarity of the air has been felt by travellers to produce the most painful effects; and even of those natives who train themselves for the purpose of crossing the mountains, some can never bring themselves to endure it. The pass remains open from the end of June till the middle of October; and during that time the most of the trade between Hindustan and Chinese Tartary is carried on by it; the merchandise being conveyed on the backs of yaks, goats, and sheep.

NIVELLES, a town of Belgium, province of South Brabant, stands on the Thienne, 17 miles S. of Brussels. It is not very well built, but has two large squares and a fine public walk. There are 3 churches; one of which, that of St Gertrude, is a fine edifice in the Romanesque style, built in 1048. It contains two finely carved pulpits, one of wood and the other of marble; and has two towers, the lower of which contains a chime of bells, on which the hours are struck by a colossal figure called *Jean de Nivelles*. The crypt is considered one of the finest in Belgium, and is much resorted to by pilgrims. Nivelles has also a convent, a college, normal school, academy of design and architecture, hospital, court of primary jurisdiction, &c. Manufactures of linen, woollen, and cotton stuffs, hats, lace, paper, oil, tobacco, and other articles are carried on here; and there is a considerable trade in corn, cattle, and swine. The town owes its origin to an abbey founded in 645 by St Gertrude, some cloisters of which still remain. It is said to have been much more populous in the sixteenth century. Pop. 8499.

NIVERNAIS, an old province of France, which comprised the present department of Nièvre and part of that of Cher.

NIXDORF, a town of Bohemia, in the circle of Leitmeritz, stands near the borders of Saxony, 34 miles N.E. of Leitmeritz. Manufactures of linen, hosiery, cutlery, and hardware are carried on; and the latter articles are exported to all parts of Germany. In the neighbourhood are mineral springs, over which baths have been erected. Pop. 5090.

NIZAM'S DOMINIONS. See HYDERABAD.

NIZZA MONFERRATO, a town in the kingdom of Sardinia, in the division of Alessandria, stands at the confluence of the Belbo and Nizza, 16 miles S.W. of Alessandria. It has a silk-mill, and some trade in wine. Pop. 4376.

NOAH. See DELUGE.

NOBILITY, in the technical acceptation of the word, means generally that quality or dignity which raises a man above the rank of a commoner. Among the Romans, the *nobiles* or "known" men, were so called by way of distinction from the *ignobiles*, or vulgar, who were "not known." Originally the Roman patricians were the nobles, but B.C. 336 the plebeians obtained the right to rise to high offices in the state, and subsequently the descendants of plebeians who had filled curule magistracies inherited the *jus imaginum*, or right of holding the images of their ancestors—a sort of coat of arms; and were accordingly ranked with the *nobiles*, and bore the dignity of *nobilitas*. He that had only his own image was a *novus homo*, and he that had neither his ancestors' nor his own was an *ignobilis*.

"The distinction of rank and honours," says Blackstone, "is necessary in every well-governed state, in order to reward such as are eminent for their services to the public, in a manner the most desirable to individuals, and yet without burden to the community; exciting thereby an ambitious yet laudable ardour, and generous emulation in others. And emulation, or virtuous ambition, is a spring of action which, however dangerous or invidious in a mere republic or under a despotic sway, will certainly be attended with good effects under a free monarchy, where, without destroying its existence, its excesses may be continually restrained by that superior power from which all honour is derived. Such a spirit, when nationally diffused, gives life and vigour to the community; it sets all the wheels of government in motion, which, under a wise regulator, may be directed to any beneficial purpose; and thereby every individual may be made subservient to the public good, while he principally means to promote his own particular views. A body of nobility is also more peculiarly necessary in our mixed and compounded constitution, in order to support the rights of both the crown and the people, by forming a barrier to withstand the encroachments of both. It creates and preserves that gradual scale of dignity which proceeds from the peasant to the prince; rising like a pyramid from a broad foundation, and diminishing to a point

Nobility. as it rises. It is this ascending and contracting proportion that adds stability to any government; for when the departure is sudden from one extreme to another, we may pronounce that state to be precarious."

The origin of nobility is a subject involved in obscurity. In the infancy of almost every nation we meet with a hereditary nobility of some sort. It originally had a reference doubtless to superior merit; and in early times is found most frequently attaching to the warrior or the priest. An interesting passage bearing on the origin of hereditary nobility occurs in the *Franca Gallia* of Francis Hotman, written in 1574. He says, "We must not omit making mention of the cunning device made use of by Hugh Capet for establishing himself in his new dominions (as king of France A.D. 987). For whereas all the magistracies and honours of the kingdom, such as dukedoms, earldoms, &c., had been hitherto, from ancient times, conferred upon select and deserving persons in the general conventions of the people, and were held only during good behaviour, whereof (as lawyers express it) they were but beneficiaries, Hugh Capet, in order to secure to himself the affections of the great men, was the first that made those honours perpetual, which were formerly but temporary, and ordained that such as obtained them should have an hereditary right in them, and might leave them to their children. Of this see Franciscus Conanus the civilian, *Comment.* i., ch. 9." (Burke's *Peerage*).

Sir James Lawrence, who, in his *Nobility of the British Gentry*, maintains that gentility is superior to nobility (*fit nobilis, nascitur generosus*), holds that a coat of arms is the criterion of nobility. (See HERALDRY.) He says (p. 3), "Any individual who distinguishes himself may be said to ennoble himself. A prince, judging an individual worthy of notice, gave him letters patent of nobility. In these letters were blazoned the arms that were to distinguish the shield. By this shield he was to be known, or *nobilis*. A plebeian had no blazonry on his shield, because he was *ignobilis*, or unworthy of notice. In an age when a warrior was cased in armour from head to foot, he could only be known by his shield. The plebeian who had no pretensions to be known was *clypeo ignobilis albo*. Hence arms are the criterion of nobility. Every nobleman must have a shield of arms. Whoever has a shield of arms is a nobleman. In every country in Europe, without exception, a grant of arms or letters of nobility is conferred on all the descendants. In the northern countries—Germany, Hungary, Russia, Sweden, Denmark—the titles also of baron or count descend to all the male posterity, and to all the unmarried females of the family; but in the southern countries—France, Spain, Portugal, and Great Britain—the titles of duke, marquess, count, viscount, or baron, descend only according to the rules of primogeniture."

In Great Britain nobility extends to the five ranks of duke, marquess, earl, viscount, and baron. (See under each.) The right of peerage seems to have been originally territorial; that is, annexed to lands, honours, castles, manors, and the like, the proprietors and possessors of which were, in right of those estates, allowed to be peers of the realm, and were summoned to Parliament to do suit and service to their sovereign; and, when the land was alienated, the dignity passed along with it as an appendage. Thus in England the bishops still sit in the House of Lords, in right of succession to certain ancient baronies annexed, or supposed to be annexed, to their episcopal lands; and thus (11 Henry VI.) the possession of the castle of Arundel was adjudged to confer an earldom on its possessor. But afterwards, when alienations became frequent, the dignity of the peerage was confined to the lineage of the party ennobled, and, instead of territorial, became personal. Actual proof of a tenure by barony became no longer necessary to constitute a lord of parliament; but the record of the writ of summons to him or his ancestors was admitted as a sufficient evidence of the tenure. Peers of Great Britain are now created either by writ or by patent; for those who claim by prescription must suppose either a writ or patent to have been issued or granted to their ancestors, though by length of time it has been lost. The first of these summonses on record was made in the forty-ninth year of Henry III.; and the first instance of barons made by letters patent dates from the reign of Richard II. The creation by writ or the king's letter is a summons to attend the House of Peers, by the style and title of that barony which the king is pleased to confer: that by patent is a royal grant to a subject of any dignity and degree of peerage. The creation by writ is the more ancient way; but a man is not ennobled thereby unless he actually take his seat in the House of Lords; and some are of opinion that there must be at least two writs of summons, and a sitting in two distinct Parliaments, to establish a hereditary barony; and therefore the most usual, because the surest way is to grant the dignity by patent, which endures to a man and his heirs according to the limitation thereof, although he himself should never make use of it. Yet it is customary to call up the eldest son of a peer to the House of Lords by writ of summons, in the name of his father's barony, because in that case there is no danger of his children losing the nobility in the event of his never taking his seat, seeing they will succeed to their grandfather. Creation by writ has also one advantage over that by patent. A person created by writ holds the dignity to himself and his heirs, without any words to that purport in the writ; but in letters patent there must be words to direct the inheritance, otherwise the dignity endures only to the grantee for life. Nobility.

The nobility of England are, as elsewhere, a privileged order. In criminal cases a nobleman must be tried by his peers—a privilege, indeed, secured to all by Magna Charta (c. 29). It is said that the privileges of nobility do not extend to bishops, who, though they are lords of Parliament, and sit there by virtue of the baronies which they hold *jure ecclesiæ*, yet are not ennobled in blood, and consequently not peers with the nobility. As to peeresses, no provision was made for their trial when accused of treason or felony till after Eleanor, Duchess of Gloucester, wife to the Lord Protector, had been accused of treason, and found guilty of witchcraft, in an ecclesiastical synod, through the intrigues of Cardinal Beaufort. This very extraordinary trial gave occasion to a special statute (20 Hen. II., c. 9) which enacted that peeresses, either in their own right or by marriage, should be tried before the same judicators as peers of the realm. If a woman, noble in her own right, marries a commoner, she still remains noble, and must be tried by her peers; but if she be only noble by marriage, then by a second marriage with a commoner she loses her dignity; for as by marriage it is gained, so by marriage it is also lost. Yet if a duchess-dowager marries a baron, she continues a duchess still; for all the nobility are *pares*, and therefore it is no degradation. A peer, or peeress, either in her own right or by marriage, cannot be arrested in civil cases; and they have likewise many peculiar privileges annexed to their peerage in the course of judicial proceedings. A peer sitting in judgment gives not his verdict upon oath, like an ordinary juryman, but upon his honour; he answers also to bills in chancery upon his honour, and not upon his oath; but when he is examined as a witness either in civil or criminal cases, he must be sworn; for the respect which the law shows to the honour of a peer does not extend so far as to overturn a settled maxim, that *in judicio non creditur nisi juratis*. The honour of peers is, however, so highly tendered by the law, that it is much more penal to spread false reports concerning them, and certain other great officers of the realm, than concerning other men; scandal against them being called by the peculiar name of *scandalum mag-*

natum, and subjected to peculiar punishment by different ancient statutes. In point of fact, however, their immunities have relation more to dignity than power. In their legislative capacity, the peers of England form an estate of the realm intermediate between the crown and the commons. In their judicial capacity they constitute the supreme court of justice, from whose judgment there is no further appeal. While bearing the minor crown, they wield no minor sceptre of personal power. They possess no regal jurisdiction, nor any sovereign seigniory. No peer can invade with impunity the rights of a commoner, nor exercise any peculiar authority not open also to the commoner. A patent of English nobility, however, confers not only a title, but also a certain amount of political power and privilege. Yet there may be nobility without political privileges, as in the case of Scotch and Irish peers, who are not peers of the realm. There are also members of the House of Lords who are not peers of the realm, as in the case of the representative peers of Ireland and Scotland, and the bishops and archbishops of England and Ireland. The peerages of Great Britain and Ireland enjoy the same privileges in all other respects, however, except those depending upon sitting in the House of Lords (39 and 40 Geo. III. cap. 67). Peers of the realm are entitled to sit there either by hereditary claim, or from being elected by their own peers; whereas the rest of the nobility in the House of Lords are nominated by the crown to places which entitle them to a seat for life, or for certain fixed periods. New additions are constantly being made to the English peerage. The persons selected for this honour are drawn chiefly from the following classes:—Peers of Scotland and Ireland; members of families already among the nobility; distinguished lawyers, and naval and military commanders; persons eminent in political life; persons of extensive landed property, and some who have acquired great wealth and attained to social importance in commerce. Hitherto distinction in science and literature has been rewarded by no higher dignity in England than that of a baronet, which does not confer nobility; but this custom was broken through in 1857, in the case of Lord Macaulay, who was elevated to the rank of nobility as a reward for distinguished literary merit.

A peer cannot lose his nobility except by death or attainder, although there was an instance, in the reign of Edward IV., of the degradation of George Neville, Duke of Bedford, by act of Parliament, on account of his poverty, which rendered him unable to support his dignity. But this is a singular instance; and while it serves to show the power of Parliament, proves how tender that august assembly has always been in exerting so high a function.

In France the titles and armorial bearings of the nobility were abolished by order of the National Assembly, June 18, 1790, and the records of the French nobility, in 600 vols., were burnt two years afterwards. Napoleon created a new nobility in 1808, but the hereditary peerage was abolished in 1831.

NOCERA DEI PAGANI, a town of Naples, province of Principato Citra, at the foot of a hill occupied by the ancient citadel, in the middle of a series of isolated heights, 21 miles E.S.E. of Naples. It consists of straggling groups of houses, with gardens and trees between; and has several churches, a convent, a clerical seminary and other schools, and good cavalry barracks. Manufactures of linen and other stuffs are carried on. Nocera occupies the site of the ancient Nuceria, which was destroyed by Hannibal in his invasion of Italy. It is supposed to have received its modern epithet from a colony of 20,000 Saracens, who were settled here in the 13th century by the Emperor Frederick II., in opposition to the court of Rome and the Guelph faction. Pop. 6800.

NOCI, a town of Naples, province of Bari, 28 miles S.E. of the town of that name. It has a large hospital; and some trade in corn, wine, oil, and silk. Pop. 8000.

NODES, the two points where the orbit of a planet or comet intersects the ecliptic, or where the orbit of a satellite intersects the orbit of its primary. (See ASTRONOMY.)

NODIER, CHARLES, a distinguished French littérateur, was born at Besançon, April 29, 1780. From his father, who was mayor of his native town during the first years of the Revolution, he received an excellent classical training. While still a mere lad, he gave earnest of his future literary eminence by composing dramas and lyrics on classical themes, which were much admired by competent judges in the circle of his friends. Encouraged by their praises, he began to point his thoughts and studies to a definite aim, and in 1798 published his *Dictionnaire des Onomatopées*. This work, which displayed research and critical power remarkable in so young a man, was, by the advice of Fourcroy, adopted as a text-book in all the government *lycées* and public schools throughout France. At this period of his life Nodier devoted much of his time to the study of natural history. He only published two works bearing directly on that science; one, an Essay on the Organs of Hearing in Insects; the other, his *Bibliothèque Entomologique;* but nearly all his more mature works give evidence of great taste and knowledge in these branches of inquiry. His next work of importance was his *Napoleone*, published in 1800. It was written in defence of freedom, at that time rapidly dying out in France under the military despotism of Bonaparte. Many of the views and expressions were extremely distasteful to the First Consul, who, after keeping the poet in confinement for some months, banished him to his native town, and there put him under police surveillance. Nodier's studies now took a philological turn, and his *Examen Critique des Dictionnaires de la Langue Française* was a valuable contribution to a science at that time much neglected in France. For several years after this date, he led an unsettled and wandering life, till he found a resting-place at Dôle. He there began a course of lectures on literary subjects; gained great popularity as a lecturer and critic; and married Mademoiselle Charvès, a young lady of great beauty and accomplishments. For some years after his marriage Nodier continued to reside at Quintigny, near the Jura, till the necessities of his family, and the prospects of abundant literary employment, drove him to settle in Paris. For some years he contributed regularly to the *Journal des Débats*, and after the restoration of the Bourbons, became editor of the *Quotidienne*. In 1818 he published *Jean Sbogar;* in the following year his beautiful romance of *Thérèse Hubert;* in 1820 *Adèle;* in 1821 *Smarra;* and in 1822 *Trilby*. These works served to establish Nodier's fame, and soon after the appearance of the last mentioned of them he was appointed to the honourable position of librarian to the Arsenal. The duties of this office were severe, and the heavy exactions on his time by society left him comparatively little time for writing. Some of his best works, however, such as his *Dernier Banquet des Girondins*, his *Fantaisies du Docteur Néophobus*, and his *Franciscus Columna*, date after his appointment to the librarianship. He died on the 27th of January 1844, almost exactly ten years after his election as a member of the French Academy. Nodier was one of the most amiable, pure, and interesting among the French littérateurs of his day. It may be doubted if even his best works are of a texture to resist the tear and wear of all time. He wrote too much, and too variously, to insure himself a place in the front ranks of French genius; but it is hardly possible to deny that, had he concentrated instead of diffusing his powers, and written for the future rather than for the passing hour, his chances of immortality might have become certainties. An interesting Life of Nodier, by his friend François Wey, was published at Paris in 1845.

NOGENT-LE-ROTROU, a town of France, depart-

Noirmoutiers ‖ Nollekens.

ment of Eure-et-Loire, at the foot of a steep hill in a beautiful valley on the left bank of the Huisne, 33 miles W.S.W. of Chartres. On the hill are the ruins of an old castle, which was once the residence of the celebrated Sully. In the town are three churches, one of which is as old as the eleventh century, three hospitals, a chamber of manufactures, a college, and a court of the first resort. There are also dye-houses and fulling-mills, as well as manufactories of leather, serge, cotton yarn, sieves, &c. An active trade is carried on in linen, hemp, clover-seed, hay, cattle, and other articles. Pop. (1856) 6542.

NOIRMOUTIERS, an island of France, off the coast of the department of Vendée, separated from the mainland by a channel about one mile in breadth, which is nearly dry at low-water. Its length is about ten miles, greatest breadth three; area about seventy square miles, of which only about one-fifth is cultivated. This part is very fertile; and the rest of the surface is occupied chiefly by pasture ground and salt marshes. The island lies generally somewhat below the level of the sea, and is protected from inundation by embankments. The principal productions are salt, corn, beans, and some wine. On the east coast stands a town of the same name, which is well built, and has an old castle and a harbour. Pop. 7011.

NOLA, a town of Naples, in the province of Terra di Lavoro, stands on the plain between Mount Vesuvius and the Apennines, fourteen miles E.N.E. of Naples. It is ill built and dirty; contains several churches and convents, a college, hospital, and barracks; and is the see of a bishop. The town is of great antiquity, and is remarkable in Roman history for the resistance it offered to Hannibal in B.C. 216, who received his first check from Marcellus under the walls of this town. Nola is also remarkable as the place where Augustus died, A.D. 14; and in the fifth century it was the see of St Paulinus, by whom church bells were introduced. Many remains of antiquity have been found at Nola. Pop. 9600.

NOLLE PROSEQUI, a phrase used in judicial proceedings, where a plaintiff in an action does not declare in a reasonable time, in which case it is usual for the defendant's attorney to enter a rule for the plaintiff to declare, after which a *non prosequitur* may be entered. A *nolle prosequi* is esteemed a voluntary confession that the plaintiff has no cause of action; and therefore if a plaintiff enters his *nolle prosequi*, he may be amerced; but if an informer cause the same to be entered, the defendant may have costs. The phrase is derived from the words used in the formal entry of the withdrawal, in which the party agrees that he will not farther prosecute (*se ulterius nolle prosequi*).

NOLLEKENS, JOSEPH, a distinguished English sculptor, was born in London on the 11th of August 1737. His father, a native of Antwerp, was a painter by profession, and is mentioned by Horace Walpole, under the name of "Old Nollekens," as an artist of some repute. He died whilst Joseph was still very young; and his widow having married again soon after his decease, the education of the youthful sculptor was much neglected. In his thirteenth year we find him in the studio of Scheemakers, where he exhibited his passion for his art by drawing and modelling early and late with the utmost assiduity. As his powers expanded, he became repeatedly a successful candidate for the prizes offered to rising genius by the Society of Arts. In his twenty-third year we find him in Rome, friendless, and nearly reduced to want, but enthusiastically pursuing his vocation. He modelled and carved in stone a bas-relief, which brought him ten guineas in England; and in the following year his group of "Timoclea before Alexander," in marble, was honoured by the Society of Arts with a premium of fifty guineas. This success placed him above absolute dependence; and he was now noticed by the artists in Rome, particularly Barry, and also by some English visitors, amongst whom were Garrick and Sterne. The great English actor recognising him one day in the Vatican, invited him to breakfast next morning, and ended by sitting to him for his bust, for the model of which Garrick paid twelve guineas to the artist. Sterne likewise sat to him at Rome; and the bust of the wit, which is in terra-cotta, is considered an admirable likeness. To the last hour of his life Nollekens alluded to it with pleasure. "Dance," he used to say, "made my picture with my hand leaning on Sterne's head; he was right." He was liberally patronized by his countrymen who annually migrated to the capital of Italy, and for whom he executed many considerable works in marble, of which "Mercury and Venus chiding Cupid" are considered as the best. For all his productions he received immediate and liberal payment. Early misfortunes had made Nollekens acquainted with privation. Being an economist from necessity, he became frugal from habit; and this continued to influence his conduct when the necessity for parsimony no longer existed. He lived at Rome in a very humble manner, and, after ten years of profitable study, he returned to London comparatively rich. Nollekens was now prepared to commence business upon his own account, and accordingly he took a lease of extensive premises in Mortimer Street. The busts of Sterne and Garrick had spread his fame in his native country, and he no sooner opened his doors than orders came in in abundance. In 1771 he was admitted an associate of the Royal Academy, and in the following year was elected a member, much to the satisfaction of George III., who soon afterwards honoured the artist by sitting for his bust. Nollekens about this time married a lady who was the friend of Samuel Johnson, and, if report may in aught be credited, the great critic was not insensible to her charms. Nollekens was fully aware that his strength lay in busts; and as this line of art was an exceedingly profitable one, it may readily be supposed that his time and talents were principally devoted to it. Amongst his sitters were the great, the beautiful, and the titled of the land; and his profits were commensurate with the condition of his employers. He also found leisure to work out, slowly and with much care, marble groups and statues, amongst which may be mentioned those of "Bacchus," "Venus taking off her sandal," "Hope leaning on an urn," "Juno," "Pætus and Arria," and "Cupid and Psyche." His portraits were excellent, and there was generally a gentleness in the expression, and a gracefulness in the handling, which never failed to please. The likenesses of his busts were acknowledged by all, and the prettiness of the statues could not fail to be as generally admitted. But original vigour was wanting. He was one in whom the merely imitative faculty greatly surpassed the imaginative. The want of imagination Nollekens partially supplied, however, by a diligent study of the antique; and hence, whilst every statue surpassed its predecessor in delicacy of workmanship, the artist only attained eminence by incessant labour. During a period of ten years, from 1776 to 1786, he exhibited sixteen busts, five statues, and four groups, some of which were not in marble. The statues were those of "Juno," "Diana," "Adonis," "Cupid," and "Mercury," in which he followed the beaten track, without attempting anything new. Amongst his monumental effigies may be mentioned that which commemorated the three commanders who fell in Rodney's great battle of the 12th April 1782. From his "Venus," and other statues of that description, we pass on to those productions which were more suitable to the genius of the artist. The ten years which followed 1800 were the busiest in the life of Nollekens; for although he was between sixty and seventy years of age, he continued to work with the same diligence and skill as in his youth. Upwards of fifty busts proceeded from his chisel, besides nearly a score of groups and statues. Amongst the former were the far-famed heads of Pitt and Fox, those of the Prince of Wales,

Nollekens.

Nombre-de-Dios || Nominalists and Realists.

afterwards George IV., Dr Burney, the Marquis of Stafford, the Duke of Bedford, and others. Of the twenty statues and groups, the statue of Pitt for Cambridge attracted most attention at the time. The "Venus anointing herself," however, was the favourite work of Nollekens, though it is deficient both in originality and in propriety of action. The workmanship of the statue, however, is very fine. From 1810 till 1816, the last year of his exertions, he modelled some thirty busts, not a few of which are ranked amongst the most valuable of his works. The principal heads are those of the Duke of York; Lords Castlereagh, Aberdeen, Erskine, Egremont, Liverpool; Canning, Perceval, Benjamin West, and Thomas Coutts the banker. Nollekens died on the 23d of April 1823, leaving a fortune of some two hundred thousand pounds. (Cunningham's *Lives of British Painters, Sculptors, and Architects*, vol. iii.) (J. F. S.)

NOMBRE-DE-DIOS, a town of Mexico, department of Durango, and 45 miles S.S.E. of the town of that name. In the vicinity there are rich silver mines; but the principal resources of the place are derived from the sale of a liquor called *mescal*, distilled from the aloe. Pop. 7000.

NOMINALISTS AND REALISTS, two opposing sects among the scholastic philosophers, celebrated for the bitter and even bloody hostility with which they maintained their disputes. The contest turned upon the nature of general terms, or *universals*. While both parties agreed that the object of the science of logic was universals, they differed upon the grand question as to whether these universals were *real* things or mere *names*. One party espoused the latter opinion, and went by the name of Nominalists; the other adopted the former view, and received the name of Realists. The Nominalist cited Aristotle in behalf of his position; the Realist adduced Plato in favour of his. It becomes therefore necessary, in order to get to the root of this famous controversy, to advert to the doctrines of those ancient masters respecting common notions or ideas. According to the opinion of Plato, common terms, as representative of the actual and eternal ideas of the Divine mind, according to which all particular existences are formed, have a real, permanent existence. The partial exponents of these ideas, as manifested in individuals, he held to be unreal and illusory; and that the only proper realities were those general notions or ideas denoted by the term *universals*. Words, according to Plato, are the means whereby we ascend to a clear and vital perception of things, and behind every common term there lurks an unquestionable reality. To seize upon this reality is accordingly the business of his dialectics. With Aristotle, again, whose philosophy was fundamentally distinct from his master's, the business of dialectics is to treat of the manner in which our minds discourse of things: words, according to him, are the representatives of our thoughts; and class words set forth in speech our notions or generalized conceptions of individuals. He therefore denied the eternal existence of Plato's ideas, but admitted with him the existence of those ideas in every individual of the species of which they formed the proper essence. As the phrases went among the schoolmen, Aristotle maintained *universalia in re;* Plato, *universalia ante rem;* the Nominalists, *universalia post rem*. Logic, with Aristotle, was the science of names and notions; with Plato it was more the science of names and realities. With Aristotle logic was an end in itself—it was the science of the laws of discursive thinking; with Plato it was simply a means whereby the eternal and only realities which lay concealed behind universals were to be laid hold of. It is curious, however, that "different philosophers," according to Sir W. Hamilton, "have maintained that Aristotle was a Realist, a Conceptualist, and a Nominalist in the strictest sense." (Hamilton's Edition of Reid's Works, p. 405, note.)

Nominalists and Realists.

At a very early period in the history of the church the Platonic ideas of being and unity had become inseparably connected with the mysteries of the Christian religion. The science of logic, as taught in the *Organum* of the Stagyrite, who was, indeed, the true founder of the science, was expounded by the doctors of the schools according to the principles of Plato, which had no proper connection with it. This practice continued until the times of St Anselm, about the end of the eleventh century, when a disputed passage in Porphyry's Introduction to the *Organum* of Aristotle, respecting the disagreement of the Platonists and Peripatetics on the nature of genera, brought matters to a crisis. Roscelinus, or Roscelin, a canon of Compèigne, maintained that the notions of universals, of genera, and species were possessed of no reality,—were nothing but mere words (*flatus vocis*) employed to designate qualities common to different individuals. By this man, and in this manner, was Nominalism founded. Although apparently a trifling dispute in itself, the theory of ideas was nevertheless a fundamental one in the scheme of human knowledge. The controversy thus excited by the canon of Compèigne had accordingly an extensive bearing. If every genus is only a mere word, it follows that individuals are the only realities, and that the senses are at bottom the only sources of knowledge. And not only so, but on this theory no absolute affirmation respecting truth is possible, for such an affirmation involves of necessity a general idea, which, *ex hypothesi*, is destitute of real validity. Hence we have scepticism at the next remove. Among churchmen, of course, all such disputes partook more or less of a theological character. The Nominalist doctrine, by denying a real validity to abstract ideas, was charged with necessitating the denial of the realities of unities, and, in particular, of the great unity which forms the basis of the Holy Trinity. If the Trinity represented only a nominal unity, then it was pretty obvious that Roscelinus, the Nominalist, was a very dangerous person indeed. The poor canon had therefore to retract, on pain of death, at the Council of Soissons in 1092. St Anselm was the first to attack the position of Roscelinus, in a work on the Unity of the Trinity, but with a degree of temperance all his own, and with a realistic creed different from that of the Realists of the schools. Seeing that Nominalism and heresy had now become synonymous, it behoved philosophic churchmen to crush the error. William of Champeaux, in order to do the work effectually, rushed straight to the opposite extreme, and, as the founder of scholastic Realism, maintained that universals, so far from possessing a merely nominal existence, were in point of fact the only real entities. Genera, according to him, individualize themselves in particular beings in such a manner that individuals differ only by the variety of their accidents, but are identical as to their essence or real nature. A few steps further and we have pantheism. Such, then, were the alternatives to which the speculations of Roscelinus and William of Champeaux reduced the thinkers of that time. Nominalism and scepticism, Realism and pantheism—such was the dilemma. Abelard, the illustrious pupil of the founder of Realism, like a wise man, chose a middle course in preference to the horn of either extreme. He ascribed a reality both to individuals and universals, but a reality differing in the case of each. Individuals had, he maintained, an essential existence, and universals an existence ideally real. Genera were abstracted from particulars, and existed in the mind in the form of notions, or (as we call them now) *concepts*, and were held together and expressed by words called *general terms*. Hence the theory termed *Conceptualism*, or conceptual Nominalism, which was really the one maintained by all succeeding Nominalists, and is the doctrine of ideas generally believed in at the present day. Abelard displeased his proud master, William, by this middle

Nomsz. course, and, as so often happens, gave satisfaction to no one. Realism accordingly triumphed in silence during the second stage of middle-age scholasticism. (See Cousin's Introduction to the unpublished works of Abelard, and his *Fragments de Phil. Scholast.*) Nominalism had well-nigh died out, when William of Occam or Ockham, an English Franciscan, and pupil of Duns Scotus, came forward in the fourteenth century to revive its decadent glory. This "invincible doctor" attacked the Realists with great spirit, and raised the doctrines of the Nominalists into greater repute than they had ever before enjoyed. Nominalism, however, was no longer upheld by Occam and his followers in its absolute form: Conceptualism is the appropriate designation for their theory. The contest between the opposing parties was now conducted with a virulence and ferocity altogether unworthy of philosophers. The strife raged in the schools of Britain, France, and Germany with the greatest fury. When words would not carry conviction, the passionate doctors had recourse to blows: when argument and patience were alike exhausted, the invincible combatants drew upon one another, and ended the quarrel in blood. The *doctor invincibilis* himself, after espousing the cause of Philippe le Bel, King of France, and of Louis of Bavaria, against the Popes Boniface VIII. and John XXII., died at Munich, "persecuted but not subdued," about the middle of the fourteenth century. Realism, as then identified with the cause of the Pope and the church, continued to prosper in Italy under the patronage of the Roman See; while Nominalism, which, from the influence of its most stanch supporter, had become identified with the political movement then agitated against the church, was generally received throughout the greater part of the European continent. But the time came when not only the University, but the King, of France issued edicts of extermination against the Nominalists. Their writings were ordered by Louis XI., in 1473, to be seized and bound in the libraries in iron chains; but after some time the edict was mitigated, the exiled sect was permitted to return, and Nominalism gained the ascendancy in France as in Germany. The fruitless and fatal consequences of these wranglings gradually became apparent. Scholasticism, with its endless subtilties and perverse ingenuities, became suspected, and a disposition towards mysticism gradually made its appearance among thinking men. (See Mysticism.) The revival of letters, and the advent of the Reformation, eventually put an end to the fiercest controversy known in the annals of philosophical speculation. Among the most celebrated Nominalists not already mentioned, were,—Durand of Saint Pourçain, John Buridan, Robert Holcot, Gregory of Rimini, and Henry of Hesse, in the fourteenth century; and Matthew of Crochove, Peter D'Ailly, Gabriel Biel, and Raymond of Sebonde, in the fifteenth. Among the Realists not already cited may be mentioned Henry of Gand, Walter Burleigh, Thomas of Strasburg, Marsile of Inghen, and Thomas of Bradwardine,—all in the fourteenth century. In addition to the ordinary histories of philosophy, the reader may consult with profit *Ueber Nominalismus u. Realismus*, von Erner, 1842; also the *Dictionnaire des Sciences Philosophiques*. (J. D—S.)

NOMSZ, Jan, a voluminous Dutch author, was born at Amsterdam in 1738, and renounced commerce to devote himself to literature. An epic poem, entitled *William I., the Founder of the Freedom of the Netherlands*, brought him into notice in 1779. Stimulated by his success, his active brain continued to produce numerous works on different subjects. He wrote satires, poetical epistles, historical sketches, newspaper articles, and translations from the French. He also composed or translated more than forty plays, which acquired great popularity on the stage of his native city. Yet all these successful efforts did not prevent him from falling into misfortune, losing his self-respect, and bringing his life to a calamitous close. He died in an hospital in 1803.

Nonagesimal ‖ Nonconformists.

NONAGESIMAL, or Nonagesimal Degree, is the highest point, or ninetieth degree of the ecliptic, reckoned from its intersection with the horizon at any time; and its altitude is equal to the angle which the ecliptic makes with the horizon at their intersection, or equal to the distance of the zenith from the pole of the ecliptic. It is much used in the calculation of the parallaxes of the moon. (See Astronomy.)

NONAGON, a nine-sided polygon. (See Geometry.)

NONCONFORMISTS, the name by which Protestant dissenters from the Church of England are generally known. Their existence dates almost as far back as that church itself. The attempt made by Henry VIII. to constitute an Anglican church differing from the Roman Catholic church only on the point of supremacy, succeeded as long as his own energy and boldness remained to support it. A system which had burnt Reformers as heretics, and hung Papists as traitors, was not likely to find much favour in a country where the popular zeal ran high in favour either of the old opinions or the new. Henry's system accordingly died with its founder; and it was reserved for the pious and courtly Cranmer to have the honour of laying the first stone of the proud edifice of the Church of England. The government and the Protestants required the mutual support of each other; and in order to a union, concessions were made on both sides. They took a middle course between Rome and Geneva, and laid the foundation of the Church of England. Her principles of theology were mainly Protestant; her prayers and thanksgivings savoured of the ancient breviaries; her government was episcopal; and the king was her head. Despite the ingenuity and good design of this compromise, it is obvious that it was calculated to give scandal not only to zealous Catholics by going too far, but also to zealous Protestants by not going far enough. It was from the latter class, accordingly, that the Nonconformists and Puritans of England afterwards sprung, who were ultimately destined to exert a powerful influence over the political as well as the religious institutions of the kingdom. If in the days of Edward VI. the discontent of this party caused the government not a little annoyance, the fiery trials through which they had to pass during the succeeding reign were not calculated to allay their scruples. The cruelties of Mary drove immense numbers of Protestants to the Continent for safety, and the majority of them found an asylum in Switzerland and Germany. A portion of them settled at Frankfort, and resolved, after some deliberation, to adopt the Genevan service-book in preference to that of King Edward. Not a few of the exiles in Strasburg and elsewhere opposed this step; and Frankfort became the theatre of a contest between the rival systems of Episcopacy and Presbytery. John Knox, who had ministered for a time to the exiles at Frankfort, was forced to flee from the scene of strife, and Episcopacy triumphed. From this dispute dates the existence of the *Puritans* or *Nonconformists;* both epithets having originated in the attitude assumed by the opponents of the Church of England. When Elizabeth came to the throne the exiles returned to England, and brought their ecclesiastical disputes along with them. The battle now began in real earnest on English soil, but no concession could be obtained from Elizabeth. She endeavoured, on the contrary, by the most vigorous policy to check the progress of this numerous, active, earnest-minded party. She occasionally even sent the more stubborn of them to prison; but so strongly were they attached to her as the mainstay of the Reformed churches, that they did not cease to pray, from the gloom of the dungeon, for the safety of her person and the victory of her arms. "The Nonconformists," says Lord Macaulay, "rigorously as she treated them, have, as a body, always

Noncon-formists.

venerated her memory." (*History of England*, vol. i.) The acts passed during Elizabeth's reign for the suppression of Nonconformity were both numerous and severe. By the Act of Uniformity (1 Eliz., c. 2), rigorous penalties were enacted against all who should perform divine worship after any other mode than that prescribed in the Book of Common Prayer. From 1558 to 1565 this law was only partially observed, but from the latter year it began to be applied in all its force. Many of the Nonconformists lost their preferments, for they had not as yet judged it advisable to separate themselves from the church. By the act 23 Eliz., cap. i., sec. 5, the Puritans were subjected to heavy fines as often as they indulged their antipathy to the Established Church by absenting themselves from its worship. The rigour of these fines was even increased by the statute of 29 Eliz., cap. 6, secs. 4, 6; and by an act of 3 Jac. I., cap. 4, sec. 11, this obnoxious enactment was rendered still more tyrannical and severe. The last statute of Elizabeth's reign which weighed heavily on Nonconformity in England was 35 Eliz., cap. 1. It converted fines into imprisonment, and even perpetual exile from the kingdom, as the penalty of non-attendance at the Established Church, or of the countenancing of conventicles. It should be noted, however, that while those provisions severely affected the Protestant Nonconformists, they were perhaps directed mainly against the Roman Catholics. During this entire reign the Puritans were not without great strength and influence in the House of Commons—an influence, moreover, that continued to increase despite the rigorous policy adopted for their suppression. And, after all, the demands of the more reasonable among them were not so very exorbitant. Not a few of them would have rested satisfied with the removal of such rites and ceremonies as they deemed a departure from the purity of Christian worship as revealed in the Scriptures. Others, with Cartwright of Cambridge at their head, were anxious for Presbytery rather than Episcopacy; while a third party—the Brownists or Independents—advocated the entire separation of church and state. The death of Elizabeth came in 1603, however, and no concessions had as yet been made to the demands of the Puritans. The high hopes raised by that much-wronged party on the accession of a Presbyterian to the throne were not destined to be realized. James I. condescended to hold conference with the Nonconformists at Hampton Court, but was more anxious to impress them with a sense of his superiority in theological disputation, than to listen to their wrongs with a view to their amelioration. The king was ingenious, but the sturdy Puritans could not be convinced. They were accordingly dismissed with insults, only to have fresh temporal and spiritual penalties issued against them in the Book of Canons of 1604. The acts of 3 Jac. I., cap. 4, and of 21 Jac. I., cap. 4, were passed to circumscribe still more the liberties of the nonconforming community, and to render their bondage yet more galling. Still, Puritanism continued to make progress in England, and the Arminianism of King James added greatly to the number of the disaffected in the bosom of the Church of England. The policy of Charles I. showed no improvement on that of his predecessors; and his bitter antagonism to the Puritans found a zealous supporter in the person of the notorious Archbishop Laud. To escape the atrocities of the Star Chamber and of the High Commission Court, not a few sought safety in voluntary exile to Massachusetts Bay, where they founded a colony, of which men still know something. But the sad relief of expatriation was soon denied them by express proclamation. Hundreds of Puritan clergymen were ejected during this reign for their hostility to the *Book of Sports:* Calvinism was denounced by the king and court; and fresh restrictions were laid upon Nonconformist preaching. Human patience, however, has its limits; and a day of dark retribution came, when the down-trodden people of England rose in their wrath to right themselves. Laud was beheaded in 1644: five years afterwards his royal master shared the same fate: the Parliament had abolished Episcopacy, and Presbyterianism had its short hour of triumph. During the Protectorate all manner of sects were tolerated: Independency prevailed in the army: Baptists and Quakers flourished: the most unheard-of visionaries sprung up; but Episcopacy remained proscribed.

Nones ‖ Nonnus.

The Restoration of 1660 placed Charles II. on the throne, and brought back the old established religion. A new "Act of Uniformity" was passed (14 Car. II., cap. 4) in August 24, 1662, excluding from its communion all non-subscribers to the doctrines of the church, and otherwise subjecting them to much suffering and cruel restriction. It is from this date that the title of Nonconformists comes most into prominence. On this occasion no fewer than 2000 ministers of the church resigned their livings rather than conform to the Thirty-nine Articles. During the same reign the Conventicle Act (16 Car. II., cap. 4), the Five Mile Act (17 Car. II., cap. 1), the Corporation Act (18 Car. II., cap. 1), and the Test Act (25 Car. II., cap. 2), fell either directly or indirectly with much severity upon the Protestant Nonconformists. The statute of 22 Car. II., cap. 1, was passed with a view to annihilate conventicles by means of fines of minute rigour and uncompromising strictness. The opening of the reign of James II. brought no relief to the Nonconformists; but, to their no small astonishment and temporary delight, the 4th of April 1687, witnessed James's arbitrary Declaration of Indulgence. This proved, however, to be only a move more cunning than wise on the part of his unfortunate Majesty, to unite the Puritans and the Church of Rome in a coalition against the Church of England. All classes of Nonconformists were now exempted from penal laws: Protestant and Roman Catholic alike enjoyed public toleration. The Protestant dissenters soon discovered, however, that their spiritual privileges had, in point of fact, been abridged rather than extended by this indulgence. If they were flattered by the favour shown them by the court, they soon discovered they had purchased this hollow honour only at the expense of treating the court religion—the religion of Rome—with a becoming tenderness and respect. This, to a genuine Puritan, was worse than gall and wormwood, and it ultimately produced its effect. The blessings of a better toleration were reserved for the reign of the Prince of Orange. By the Toleration Act of 1 Wm. III., cap. 18, all Protestant dissenters, except those who denied the Trinity, were relieved from the penal statutes to which they had been subjected. The benefits of this act were afterwards somewhat circumscribed by the Occasional Communion Bill and by the Schism Bill. The latter was repealed, however, in the reign of Geo. III. (19 Geo. III., cap. 24); and the Corporation and Test Acts were abolished in the reign of Geo. IV. (9 Geo. IV., cap. 17). These and other improvements, together with the passing of the statutes relating to registration and marriage, have now placed dissenters in England in the enjoyment of full liberty of conscience in the matter of religious worship. (Special and detailed accounts of the various sects of the Nonconformists will be found under the articles Baptists, Independents, Methodists, Presbyterians, and Quakers. See Price's *History of Protestant Nonconformity in England*, 2 vols., London, 1838; and Macaulay's *History of England.*)

NONES, one of the three divisions of the Roman month. (See Calendar.)

NONJURORS, those clergymen who refused to take the oaths to the new government after the Revolution, and who were in consequence subject to certain incapacities and liable to certain penalties. (See Britain, *History of.*)

NONNUS, a Greek poet, was a native of Panopolis in

Nooaheeva || Norberg.

Egypt, and flourished in the fifth century A.D. It is likely that he was still a pagan when he wrote the former of his two extant works, the epic poem *Dionysiaca*. Then having been converted to Christianity, and probably resolving to consecrate his talents to the support of the new faith, he composed his hexameter paraphrase of the Gospel of St John. The epic is chiefly characterized by a cumbrous and disjointed plot, which runs lumbering on through forty-eight books amid much inflated verbiage and numerous inappropriate episodes. The paraphrase is valuable only on account of some of the various readings which it furnishes. The latest edition of the former of these works is that of F. Graefe, in 2 vols. 8vo, Leipsic, 1819–26. The latest edition of the latter is that of Passow, Leipsic, 1834.

NOOAHEEVA, Nouheva, or Nouka-Hiva, the largest of the Marquesas Islands, is in S. Lat. 8. 53., W. Long. 139. 49.; and has a length of about 18 miles. The surface is rugged and mountainous, and the coasts steep; the whole island being apparently of volcanic origin. The soil is rich and deep in the valleys, but on the hills it is thin, producing only tufts of coarse grass. Bananas and cocoa-nut trees grow in abundance; but as the inhabitants, who are very lazy, are supplied with food by the spontaneous productions of the soil, the only article that is cultivated is tobacco. The people are of a dark copper colour, and live in huts of wood or cane raised above the ground on a platform of stones. There are several tribes in the island, who are very warlike, and are believed to be cannibals. No trace of any religion is to be observed; and the utmost licentiousness seems to prevail. The population is variously estimated from 8000 to 18,000.

NOODT, Gerard, a celebrated jurist, was born at Nimeguen in 1647. He began his studies in his native town, and finished them at Franeker, by taking his degree in law. A successful defence of two criminals, who were arraigned at the bar for murder, first gave him a start in his profession. After passing through several successive grades of promotion, he was ultimately appointed a law professor at Leyden. But it was in the character of a writer on jurisprudence that his talents and acquirements were chiefly displayed. His Latin style, modelled after the best writers, was pure and precise; he had an intimate acquaintance with the laws, manners, and customs of ancient Rome; his speculations were guided by a simple desire for truth, and by a wary dread of dogmatic conjecture; and his political opinions were animated by a spirit of Catholic toleration. Accordingly his numerous works, as they successively appeared, rose to the rank of standard authorities. Two of the most popular among them were translated into French by Barbeyrac, and appeared at Amsterdam in 1707 and 1714, under the respective titles of *Pouvoir des Souverains*, and *Liberté de Conscience*. Noodt was still actively engaged in adding to the number of his treatises when he was cut off in 1725. His entire works, accompanied with a Life, were published by Barbeyrac, in 2 vols. fol., Leyden, 1735, and reprinted at the same place in 1760.

NOOTKA SOUND, an inlet of British North America, on the W. coast of Vancouver Island; N. Lat. 49. 35., W. Long. 126. 35. It stretches in a N.N.E. direction for 10 miles, and forms a number of smaller bays and coves. There is a wooded island in the centre; and the greatest breadth of water is not more than a quarter of a mile. The shores are rocky, and the bay forms a very safe harbour, but is not capable of accommodating more than two vessels.

NORBERG, or Nordberg, George, the historian of Charles XII. of Sweden, was born at Stockholm in 1677. Having entered into holy orders, after the usual course of study at Upsal, he was appointed almoner to the army of Charles XII. in 1703, and was promoted to the office of chaplain to the king in 1707. He continued to hold this latter post till he was carried away from the field of Pultawa in 1709 to a captivity of six years in Russia. All this while it had been his custom to keep a record of the principal incidents that came under his observation. Accordingly, several years after he had been settled down in a pastoral charge in his native city, he was employed by Queen Ulrica Eleonora to write the history of her deceased brother, Charles XII. The work, after undergoing royal inspection and revision, was published in 2 vols. fol., Stockholm, 1740, and reappeared in a French translation in 3 vols. 4to, the Hague, 1742. Two years after this latter date the author died at Stockholm.

Norcia || Nord.

NORCIA, a town in the Papal States, delegation of Spoleto, in a lofty valley near the source of the Nar, 17 miles E.N.E. of Spoleto. It has a considerable trade in pigs, oil, wine, and other agricultural produce. Pop. 4000.

NORD, a department of France, so called from its being the most northerly in the country, lies between N. Lat. 49. 58. and 51. 5., E. Long. 2. 7. and 4. 23.; and is bounded on the N. by the German Ocean, N.E. and E. by Belgium, S. by Aisne and Somme, and S.W. by Pas de Calais. Its length from N.W. to S.E. is about 124 miles; the breadth varies from 2½ to 39 miles; area, 2192 square miles. The whole surface consists of a flat and monotonous plain, slightly sloping towards the N.E., and diversified with a few hills, which do not exceed 400 feet in height. The south-eastern part of the department is occupied by the northern slopes of the mountains and the forests of Ardenne; and throughout the whole extent of the country cultivation is carried to the top of the highest elevations. The coast of the German Ocean is formed by a range of sand-hills, called *dunes* or downs, and the land beyond is little, if at all, above the level of the sea. The principal rivers flow N.E. towards the German Ocean, and owing to the flatness of the country are of a very sluggish nature. The principal of these are,—Ysser, Lys, Scarpe, Scheldt, and Sambre. The Aa, which has a N.W. direction, separates the departments of Nord and Pas de Calais. The soil is generally very good; and near the coast, where the low land is of a marshy nature, a skilful system of drainage has rendered that not only fit for cultivation, but has reclaimed from the water a tract of great fertility. Part of this district, called the Watteringhes, has been drained from a very early period by canals of various sizes,—some natural and some artificial,—which convey the water of the marshes into the sea at low-water. This district comprises an area of 195,321 acres, and is divided into four sections, each under the superintendence of special commissioners to see that the works are kept in repair. The other portion of the marshy ground lies partly in France and partly in Belgium, and is known by the name of Moeres. It consists of a larger and a smaller Moere—the former having an area of 7664 acres, of which 2944 are in France; while the latter extends only to 433 acres. This ground has on several occasions been drained, and again laid under water for the protection of the frontier, but was finally recovered from the sea in 1826. The soil of Nord consists of rich alluvial earth in the northern part, and towards the south is of a calcareous and clayey nature. The principal minerals are iron, coal, marble, paving-stones, potters' clay, &c. Cultivation is more largely and better carried on here than in most other parts of France; about 890,000 acres are occupied by arable land, 235,000 by meadows, 86,500 by wood, &c. The crops principally raised consist of wheat, rye, barley, oats, pulse, hemp, flax, tobacco, hops, &c. Pastoral occupations are also largely pursued. The horses, estimated at 80,000, are strong and fit for farm labour; the horned cattle, of which there are 230,000 head, are of one of the best breeds in France; and the 240,000 sheep of the department produce excellent wool. There are also 75,000 pigs and 7000 goats. The mineral operations carried on in this department are probably the most extensive in

France, consisting principally in the working of coal and iron mines. The manufactures are many and varied; linen, cotton, and woollen stuffs of all kinds; lace, tulle, cambric, and lawn; sugar, starch, soap, oil, glass, paper, earthenware, ropes, leather, cannon, &c. The commerce of the department is also very great, consisting of the exportation of the produce of the soil and of the manufactures, and in the importation of cotton, wool, flax, tobacco, wine, brandy, timber, &c., which are received from foreign countries and from the French colonies. There are two seaports on the German Ocean, Dunkirk and Gravelines,—at the former of which the maritime trade is chiefly carried on. The people near the coast are employed to a large extent in the herring fishery; and many vessels are sent out from Dunkirk and Gravelines to the whale and cod fisheries. In no part of France are the internal communications so much facilitated by roads and canals as in this department, where there are 15 imperial roads, extending over 360 miles; 17 departmental roads of 176 miles; besides 6 navigable rivers and 23 canals, with a total length of 350 miles. There are also 4 principal railways, extending over 143 miles. Nord forms the diocese of the Archbishop of Cambrai, and contains 5 Protestant places of worship and a Jewish synagogue. It has a court of appeal, 7 courts of primary jurisdiction, 4 tribunals of commerce, and 7 councils of *prud'hommes*. The educational institutions are,—a primary normal school at Douai, 2 academies, 15 communal colleges, 934 public primary schools, &c. There are also 47 hospitals, 2 deaf-and-dumb institutions, 3 lunatic asylums and other charitable establishments, 9 prisons, and 13 fortified places. The capital is Lille; and the department is divided into 7 arrondissements as follows:—

	Cantons.	Communes.	Population, 1856.
Lille	16	132	404,279
Douai	6	66	106,155
Dunkirk	7	59	105,717
Hazebrouck	7	53	102,734
Avesnes	10	153	150,523
Valenciennes	7	81	163,082
Cambrai	7	118	179,863
Total	60	662	1,212,353

NORD, CÔTES DU. See CÔTES DU NORD.

NORDEN, a town of Hanover, in the province of Aurich, on a canal leading to the Bay of Leisand, in the German Ocean, which is 4 miles off, 16 miles N. of Emden, and 15 N.W. of Aurich. It is an ancient and well-built town, with a large market-place planted with fine trees. There are churches belonging to the Lutherans, Reformed Church, Roman Catholics, Moravians, and Mennonites; a synagogue; an hospital, which was formerly a convent; and a school. Norden has numerous breweries; manufactories of cloth, leather, and tobacco; and a considerable shipping trade. Markets for horses are held here. Pop. (1852) 6188.

NORDHAUSEN, a town of Prussian Saxony, in the government of Erfurt, stands on the Zorge, at the foot of the Seyersberg, a branch of the Harz Mountains, and at the head of the fertile valley called the *Güldene Aue*, or Golden Valley, 38 miles N.N.W. of Erfurt, and 49 W. of Halle. It has an antique appearance, and is surrounded by walls and towers, with seven gates. There are a Roman Catholic and several Protestant churches, one of the latter containing two paintings by Cranach; a town-hall; a theatre; 4 hospitals; and several schools. Nordhausen contains distilleries, which are among the largest in Germany; besides tanneries, woollen factories, soap-works, oil-mills, and manufactories of linen, hats, sealing-wax, vitriol, and chemical substances. An active trade is carried on here in corn and cattle. Wolf, the famous classical scholar, was born in the neighbourhood of Nordhausen. Pop. 14,960.

NORDHEIM, a town of Hanover, in the province of Hildesheim, on the left bank of the Ruhme, 12 miles N. of Göttingen. It is well built, and defended by walls. There are saw-mills, and manufactories of cloth, leather, shoes, and tobacco. Some trade is carried on in timber. In the neighbourhood there are sulphureous springs. Pop. (1852) 4679.

NORDKÖPING, or NORRKÖPING, a town of Sweden, in the *län* of Linköping, near the mouth of the Motala, in the Bravik, an inlet of the Baltic, 24 miles N.E. of Linköping, and about 90 S.W. of Stockholm. It has a beautiful situation on both sides of the river, which here incloses two islands, and is crossed by several bridges. The streets are broad, straight, well paved, and lined with neat houses, generally only two storeys high, built some of wood and some of stone. There are three churches, a town-hall, a synagogue, an hospital, and several schools. Manufactures of linen, cotton, and woollen cloth, paper, starch, soap, tobacco, sugar, brass, hardware, &c., are carried on here; and there are docks for ship-building, in which many fine steamers have been constructed. A considerable trade is carried on in the exportation of iron, grain, and manufactured articles. Pop. about 12,000.

NORDLINGEN, a walled town of Bavaria, in the circle of Swabia, on the Eger, 39 miles N.W. of Augsburg, and 48 S.W. of Nuremberg. It has 4 churches, one of which, completed in 1505, has a tower 268 feet high, and contains in the interior a fine organ and some paintings; a town-hall; an hospital; and several schools. Manufactures of carpets, woollen and linen cloth, leather, and glue, are carried on here; and the place is remarkable for its geese, in the feathers of which, as well as in cattle, an extensive trade is carried on. Nordlingen is historically important for the victory gained here in 1634 by the Austrians and Bavarians over the Swedes. A fresco painting of the battle adorns the town-hall. Pop. 7000.

NORE, a part of the estuary of the Thames, to the E. of Sheerness, and about 50 miles below London.

NORFOLK, an English maritime county, the most easterly and the fourth in territorial extent in the country, and tenth as regards population. It is bounded on the N. and N.E. by the German Ocean; on the N.W. by the estuary called the Wash; and on the S. the rivers Waveney and Little Ouse divide it from Suffolk; while the Great Ouse, the Wilney, and the Nene separate it from Cambridgeshire. Its greatest length is about 70 miles from E. to W., and the broadest part is 42 miles from N. to S. It lies between 50. 17. and 52. 56. N. Lat., and 0. 1. and 1. 45. E. Long.; is about 180 miles in circumference; and contains within the county proper (as distinguished from the registration county) 1,354,301 acres; is divided into 33 hundreds and 740 parishes, including the city of Norwich, which is a city and county in itself.

The population, according to the returns at the six decennial enumerations, amounted in 1801 to 271,125, in 1811 to 288,305, in 1821 to 339,885, in 1831 to 384,142, in 1841 to 405,124, in 1851 to 433,716. Census returns.

The census of 1851 returns the registration county as follows:[1]—

Area in statute acres.	Inhabited Houses.	Uninhab. Houses.	Houses building.	Population.	Males.	Females.
1,300,311	91,144	3360	447	433,716	210,759	222,957

The amount of real property assessed to the property and income tax in 1851 was L.2,463,893, and the amount

[1] These computations are founded on the principle adopted at the last census, which was taken in accordance with statutes 2 and 3 Will. IV., c. 64, and 7 and 8 Vict., c. 61, which altered the limits of counties, and made them consist of groups of registration districts, in general identical with poor-law unions. All isolated portions of counties are now considered part of the county surrounding them, or with which they have the greatest common boundary. Norfolk, by this arrangement, has been diminished in area, the extensive parish of Upwell having been detached from it and added to Cambridgeshire.

Norfolk. assessed to the relief of the poor for the year ending March 1850 was L.1,865,216. The expenditure of the county for 1856 was—

For Gaols	L.6,407	18	10
Administration of Justice	4,201	5	10
Lunatic Asylums	1,770	17	7
Coroners	1,071	14	9
Militia and Artillery	1,124	18	6
Miscellaneous	2,623	10	11
	17,200	6	5
The county rate levies amounted to	L.13,393	0	0
And the receipts from Government to	3,544	0	0

The births in 1851 were 14,345, deaths 9384, and marriages 3177. The places of worship were—belonging to the Church of England, 719; and sittings, 187,210: belonging to other denominations, 722; and sittings, 125,703.

There are about 100 endowed schools in connection with the Church of England, and above 1200 day schools of all denominations. The educational census gives the number of children of all ages at school—boys, 26,694; girls, 26,299. The Sunday schools are returned as 782; and Sunday scholars, 50,182. The general census gives the total number of children under ten years of age—boys, 52,996; girls, 53,082: and the total number under tuition at home or at school—boys, 17,990; girls, 17,271: leaving 70,817, inclusive of infants, not under any instruction.

Physical characteristics. From its exposure to the North Sea, the climate of Norfolk is generally colder than other parts of England, and the prevalence of easterly winds in the spring retards the growth of vegetation to a later period than in the western districts. The surface of the country presents less variety than most of the other English counties, being generally flat, and uninteresting to the traveller in search of the picturesque. The coast is chiefly comprised of low sandy beach, seldom rising into bold elevations. The only lofty cliffs are St Edmund's Point at Hunstanton, and the chalk and clay cliffs at Cromer, which are fast yielding to the incursions of the ocean. The scenery is not woody; but of late years timber has been more generally planted, for use as well as ornament, than was formerly the case. The rivers, although slow and sluggish in their course, are easy of navigation, and, with the sea on the northern and eastern sides, form natural water-boundaries to this county, making it almost an island; in the eastern valleys the streams frequently expand into large *meres* or *broads* abounding with fish. The Great Ouse, navigable for barges 24 miles from its mouth, rises in Northamptonshire, enters this county at Downham, and enters the large estuary of the Wash, which divides Norfolk from Lincolnshire, near Lynn. It affords water communication with seven of the midland counties. The Little Ouse and the Waveney rise within ten feet of each other in the southern part of the county, but pursue directly opposite courses, forming the boundary line between Norfolk and Suffolk until the Little Ouse meets the Great Ouse on the borders of Cambridgeshire, and the Waveney, becoming navigable at Bungay, meets the Yare at Burgh, and falls into the sea at Yarmouth. The Bure rises near Aylsham, and, after receiving the Thurne and Ant, falls into the Yare, which rises near Attleburgh, becomes navigable at Norwich, and, after receiving the waters of the Tass and the Wensum, merges in the Waveney. A ship-canal has been cut across the marshes from Reedham to Lowestoft in Suffolk, connecting the Yare with the sea. The Nar rises near Litcham, and has a short course to the sea near Lynn, whence it is navigable to Narborough, a distance of sixteen miles.

Parliamentary divisions. The Reform Act divided the county into two parts, East and West Norfolk, each returning two knights of the shire to Parliament. The eastern division comprises eighteen out of the thirty-three hundreds into which the county is divided, and its polling-places are Norwich, Yarmouth, Loddon, Long Stratton, Reepham, and North Walsham. West Norfolk comprises fifteen hundreds, and its polling-places are East Dereham, Fakenham, Lynn, Downham, Thetford, and Swaffham; the latter of which is the principal place of election. Norfolk.

The municipal boroughs and corporate towns of Norfolk, each also returning two members to Parliament, are—

	Inhabited Houses.	Population.
Norwich	14,988	68,195
Great Yarmouth, with Gorleston	6,886	30,879
King's Lynn	3,845	19,355
Thetford	844	4,075

Agriculture. The agriculture of this county is the foundation of its industrial prosperity. Few counties of England possess a greater variety of soils, and the peculiar excellence of the far-famed Norfolk agriculturist consists in the skill with which he *mixes* these various soils, thereby improving the *texture*, and therefore the productive qualities of all. By judicious claying and marling, large tracts of light sandy desert, moor, and heath have been converted into rich arable land; and by the extensive use of draining-mills, both wind and steam, the low marsh lands have been converted into rich valleys of fruitful corn-fields. Ten years ago it was said of the agriculturists of this county, that they knew as much as would be necessary, if known generally, to make England produce half as much again as it was at that time doing. The more general diffusion of agricultural science since that time may have lessened the comparative superiority of the Norfolk farmers, but, as they took the lead in throwing off the fetters of antiquated systems, they continue to preserve their character for adopting readily all hints for improvement, and still exhibit examples of the most judicious practices in husbandry. The ploughing and drilling here are excellent; even indifferent skill in these branches is very rare. The ploughs used are of light construction, drawn by two horses, or frequently bullocks, for which a peculiar breed of Devons are employed, and driven from behind with reins by the man who guides. This mode of driving is said to be the cause of the straightness of the lines preserved by both ploughs and drills. The most prevalent system of cropping now is the four-course, as first introduced by the late Earl of Leicester; and the usual rotation is, turnips, barley, clover or other grasses, and wheat. The five-course system is not uncommon, but the old six-course is very rare. Nearly all the corn is stacked in the field.

The number of farms in the county employing labourers is 4868; those not employing labourers, or not making returns, 1664—total, 6532. Number of labourers employed in the field—men, 32,840; women, 606—total, 33,446. Upwards of 200,000 acres of commons and sandy heaths have been inclosed during the last eighty years.

The average yield per acre[1] is ten cooms or five quarters of barley, and nine cooms or four and a half quarters of wheat. Above 1,045,760 acres of land are under cultivation. Its agricultural productions are chiefly wheat, barley, oats, peas, beans, potatoes, turnips, mangel-wurzel, beet, hay (composed of rye-grass, clover, suckling, trefoil, or sainfoin). Hemp is grown on the borders of Suffolk, and flax is cultivated for the sake of the linseed to fatten cattle, as well as for the flax itself. The management of the turnip crop is a point on which Norfolk agriculturists have long been pre-eminent. This valuable root was first introduced into field culture in the reign of George I. by Viscount Townshend, upon his estates in Norfolk. By the immense stock of winter food they supply, an enormous increase in the number of cattle and sheep bred and fattened in the county has been produced. The principal implements used in husbandry here are light ploughs, scarifiers, harrows, drills, horse-hoes, chaff-cutters, and threshing-machines. Wheat is often dibbled, the women and girls finding em-

[1] In 1831 the average yield of wheat was 3 quarters to the acre, showing an increase of 50 per cent. since that period.

Norfolk. ployment in dropping the seed. The quantity of grain exported from the various ports of the county before the opening of railways has been nearly 600,000 quarters in a year, but since that time the exports have much diminished. The principal market of the county is held at Norwich, for cattle, corn, and sheep. For the year ending October 1857, the amount of wheat brought to the Norwich market was 270,768 quarters, and of barley 187,245 quarters. The Norwich cattle-market is one of the largest in England; but the live stock of the county possess few distinctive characteristics. The principal cattle bred are Durhams or short-horns, but many Scotch and Irish are sent over to be grazed. Devons are used for ploughing, on account of their quicker step and activity. There are but few dairies, and these are confined to the neighbourhood of large towns. The indigenous breed of Norfolk sheep is now almost extinct, their hardy habits and agile movements, which were virtues when land was less cultivated, becoming defects when quickness of fattening became the primary quality requisite. The sheep now chiefly bred are Downs and half-bred Downs. The cart-horses are a fine breed, averaging from 14 to 15 hands high. Norfolk pigs are comparatively small; the finest now in the county are descended from the Berkshire boar and Chinese pigs. Poultry of all kinds is plentiful, and of a superior quality. The turkeys are most highly prized; vast quantities are sent to the London markets. No county is better stocked with game, especially pheasants and partridges, which are sedulously preserved by the landlords, and generally reserved in the leases. Great numbers of rabbits are bred in extensive warrens in many parts of the county.

From the earliest times Norfolk has been the seat of manufacturing operations. For four centuries it was the main centre of the woollen trade, first introduced by a colony of Dutch weavers, who crossed the Channel, and settled themselves at Worsted, a village about 13 miles from Norwich. The sumptuary laws of Edward III., and the fixing of staples at Norwich, tended to the increase of the manufactures; and the persecutions of the Duke of Alva, which drove large numbers of Dutch and other artizans to these shores, promoted the prosperity of the county. The most flourishing period of Norfolk woollen manufactures was during the middle of the last century. Bombazines, crapes, paramattas, and silk goods of every description, are now made. From the absence of coal and iron in the district, the manufacturers cannot compete with the north for cheapness, but for quality their goods are yet unrivalled. The number of wool-staplers and woollen manufacturers in Norfolk, returned in the last census, was 587; silk do., and dealers in silk, 2269; engaged in flax, 146; in cotton manufactures, 383; rope and hemp, 863. Besides silk and woollen manufactures, many other very important factories have sprung up; as shoes, soap, paper, brushes, bricks, tobacco, starch, mustard, oil-cake, and many varieties of artificial manures. The fishing trade of Yarmouth is an important branch of Norfolk commerce. The mackerel fishing alone is estimated to produce L.16,000 a year, employing 90 boats and 870 men. The number of fishermen in the county is 1340; fishmongers, 329. The herring fishery employs 160 boats and 1300 men, besides those on shore, and produces 100,000 barrels yearly. Yarmouth has also extensive malting establishments.

Of various kinds of produce, the quantity sent by railways to all parts of the kingdom, and exported from Lynn, Wells, and Yarmouth, is very great.

Norfolk has railway communication with London *via* Cambridge and *via* Ipswich from Yarmouth and from Lynn; and with the north and north-west of England *via* Peterborough branch from Ely.

The public and turnpike roads of the county are better than in most parts of England, being generally raised higher than the adjacent land, and well drained by trenches on either side. Norfolk.

Norfolk is in the diocese of Norwich, and in the archiepiscopal province of Canterbury. It is the head of the judicial circuit of Norfolk, which comprises five other counties. The military and maritime government of the county is vested in the same individual. The Earl of Leicester is the present lord-lieutenant, *custos rotulorum*, and vice-admiral. In the two first capacities he presides over the affairs of the county, has the control of the militia, and the appointment of deputy-lieutenants and magistrates. As vice-admiral of Norfolk he executes his authority under the Lord High Admiral of England. The mayors of Yarmouth and Lynn have admiralty jurisdiction on the rivers of their respective boroughs and ports. In 1839 a rural police, or constabulary force, was established in the county, consisting of a chief constable and 136 subordinates. The force has been at various times augmented; and in 1857consisted of one chief constable, one deputy-constable, and 219 subordinates; the total cost of whose maintenance, inclusive of all expenses connected with stations, &c., was L.15,511 for the year ending October 1857. A comparison of the statistics of crime gives 686 cases of detected felonies in 1854, and 237 cases of undetected felonies. In 1857 felonies detected were 600; undetected, 199. The families receiving titles from places in Norfolk are the Howards, dukes of Norfolk; the Gordons, earls of Norwich; Conways, earls of Yarmouth. Thetford confers the title of Viscount on the Fitzroys. The Townshends are viscounts of Raynham, and barons of King's Lynn. The De Greys are barons of Walsingham, the Nelsons barons of Hilsborough, the Howards are barons of Castle Rising, the Hobarts barons of Blickling, the Calthorpes are barons of Calthorpe, the Walpoles barons of Wolterton and Walpole, the Harbords are barons of Suffield, and the Wodehouses barons of Kimberley.

The most remarkable ancient mansions, some of which, however, exist but in ruins, are Blickling Hall, Caistor Hall, Oxburgh Hall, Winwall House, Stiffkey Hall, Baconsthorpe Hall, Hunstanton Hall, Scales Hall, Fincham Hall, Thorpe Hall, Wallington Hall, and Merton Hall; many of which exhibit the castellated character, though they do not appear to have been regularly fortified.

The principal country seats of noblemen and gentlemen are:—Beeston Hall, Sir J. H. Preston, Bart.; Blickling, Marquis of Lothian; Buckenham Tofts, Lord Ashburton; Castle Rising, Hon. F. G. Howard; Costessey Hall, Lord Stafford; Elmham Hall, Lord Sondes; Gunton House, Lord Suffield; Harling Hall, Lord Colborne; Haveringland, E. Fellowes, Esq., M.P.; Heydon Hall, W. E. L. Bulwer, Esq.; Hillington Hall, Sir W. T. H. B. Ffolkes, Bart.; Holkham, Earl of Leicester; Honingham, Lord Bayning; Houghton, Marquis Cholmondeley; Keswick Hall, Hudson Gurney, Esq.; Ketteringham, Sir J. P. Boileau; Kimberley, Lord Wodehouse; Kirby Cave, Lord Berners; Langley, Sir W. B. Proctor; Melton Constable, Lord Hastings; Merton Hall, Lord Walsingham; Oxburgh, Sir J. P. Bedingfeld, Bart.; Quiddenham, Earl of Albemarle; Raynham, Marquis of Townshend; Scottow, Sir T. H. E. Durrant, Bart.; Wolterton, Earl of Orford.

Norfolk possesses few of the more important Celtic remains common on the western coast of the island; but barrows with their contents, celts, spear-heads, beads, and other vestiges of the ruder times, are found scattered throughout the whole surface. Of the Roman period, Caistor, by Norwich, is an interesting relic: its walls and towers mark it for one of those permanent stations, known by the name of *Castra Hiberna*, and hardly to be found beyond the limits of Britain. Of summer camps, Brancaster, Castle Rising, and Tasburgh exhibit more or less perfect vestiges; while coins and urns, glass and pottery, tes-

Norfolk ‖ Norfolk Island.

tify in a variety of localities to the former presence of the Romans. Numerous traces of Danish, Saxon, and Norman times present themselves over the whole county, both ecclesiastical and civil. Thetford Castle is a remarkable specimen of a Roman fortification; and as a sacred Norman edifice Norwich cathedral has few rivals in England. Many parochial churches in the county also remain as specimens of the Norman style. Binham Priory, and parts of the Abbey of Walsingham, are specimens of early English architecture; as also are Yarmouth and other parish churches; while noble specimens of the decorated and perpendicular periods abound in every direction. Another leading feature of the antiquities of Norfolk are the painted roodloft screens and magnificent brasses. Among the most interesting remnants of civil and domestic architecture may be enumerated the castle at Castle Rising, the only known building of that description in the kingdom; Caistor and Oxburgh Halls; the walls of Norwich, Yarmouth, and Lynn; the ruins of the bishop's palace garden; and the gates of the Close, Norwich.

At the time of the Reformation Norfolk possessed no fewer than 123 monastic institutions, abbeys, priories, nunneries, colleges, and hospitals. Many were richly endowed. Some interesting ruins still remain in the county; and the general ecclesiastical architecture presents many curious and interesting specimens to the antiquary. Above 120 round towers remain in various parts. Flint is the prevailing material of which they are constructed, through the scarcity of stone in East Anglia. The tithes in most of the parishes of Norfolk have been commuted for fixed annual rents.

Among many other distinguished natives of the county we may enumerate Queen Anne Boleyn, born at Blickling; Archbishops Parker and Herring; Bishop Maltby; Lord Nelson; Dr Samuel Clarke; Sir Edward Coke; Porson; Sir Robert Walpole; Mrs Fry; Crome the artist; Lindley, Hooker, and Sir James Smith, botanists; Mrs Opie; General Wilson, the hero of Delhi. (S. S. M.)

Norfolk, a town of the United States of North America, Virginia, on the north bank of the Elizabeth River, 32 miles from the sea, and 106 S.E. of Richmond. The site is low and flat; the streets are broad, but somewhat irregular, and lined with handsome houses of stone or brick. The City Hall is adorned in front with six granite columns, and has a dome 110 feet high; the Mechanics' Hall is a building in the Gothic, and the Military Academy in the Grecian style. There are fourteen churches, one of which has a spire 200 feet high, nine seminaries, two reading-rooms, three banks, an hospital, and an orphan asylum. The harbour is large, secure, easily entered, and defended by two forts. Norfolk is the principal commercial town in Virginia, and, along with Portsmouth, on the other side of the river, the chief naval station in the United States. Its trade is facilitated by the canal through the Dismal Swamp to the south, and communication is kept up with New York and Philadelphia by steamers. The shipping of the harbour, 30th June 1852, had a total tonnage of 7716 registered, and 14,448 licensed and enrolled. The number of vessels that entered in that year was 85, tonnage 20,778; those that cleared 129, tonnage 24,447. In the same year six vessels were admeasured, with a tonnage of 408. Pop. (1850) 14,326; (1853) about 16,000.

Norfolk Island is the largest of a group of islands in the South Pacific Ocean, consisting of Norfolk, Nepean, and Philip islands, together with several scattered islets, or rather bare rocks, called the Bird Islands; S. Lat. (of the settlement on the south of Norfolk Island) 29. 10., E. Long. 167. 58. It is 600 miles W.N.W. of Auckland, and 900 N.E. of Sydney. These islands appear to rise from the surface of a submarine table-land, which extends for 18 miles to the N. and 25 to the S. of the group, with an average breadth of 18 miles, and an area of nearly 1000 square miles. The depth of water over this tract is remarkably uniform, not varying more than five fathoms; and it rises abruptly about 1000 or 1200 feet from the bottom of the surrounding ocean. Philip Island is about 3½ miles south of Norfolk Island, and is of basaltic formation, rising to the height of 900 feet at the south, and sloping towards the north. Its area is about 500 acres. Nepean Island, which is separated by a channel 800 yards wide from the largest of the group, is entirely of coralline structure, and has a height of about 50 feet from the sea, and an area of 12 acres. Norfolk Island itself is not quite 5 miles in length, with an average breadth of 2½. Its area is about 8960 acres, and its general elevation is about 400 feet above the sea, while in the N.W. the double summit of Mount Pitt attains the height of 1050 feet. The surface is broken by numerous gullies with steeply-sloping sides, and through these flow several streams, two of which have formed, by the accumulation of soil between the sea and the hills, a narrow strip of level ground, on which the settlement stands. The soil, consisting of decomposed basalt, is everywhere extremely rich; even on the higher parts it is fertile, and in the valleys the vegetation is most luxuriant. The principal tree, the Norfolk Island pine, resembling in appearance the Norway spruce, grows on all parts of the island, and attains in some places a height of 200 feet, and a circumference of 30 feet. Maple, ironwood, a small species of palm called the Norfolk Island cabbage-tree, and a fern having a height of 40 feet and fronds 11 feet in length, also grow in abundance. The underwood of the forests consists chiefly of lemons and guavas; and many plants originally exotics now grow wild here. Bananas, yams, sweet potatoes, and arrow-root, though tropical plants, flourish on the island; and oranges, coffee, maize, and rye may be raised. The amount of land under cultivation on the 31st December 1852 was 16 acres of sweet potatoes, 40 of maize, and 2 of garden ground. All sorts of domestic poultry thrive here; and there are bees which produce excellent honey. There were, on the 31st December 1852, 30 horses, 721 horned cattle, 4140 sheep, and 125 swine; but a considerable number of these have since been removed. The climate is healthy, and the heat is tempered by the sea-breeze: the temperature is rarely below 65°. Excellent roads have been made across the island in various directions, and bridges across the streams; while extensive farm buildings of a solid nature have been erected in various places. Norfolk Island, originally uninhabited, was first visited by Captain Cook in 1774; and in 1787 it was colonized partly by convicts aud partly by freemen from New South Wales; but in 1810 it was abandoned, and all the buildings were destroyed. In 1825 it was again used as a penal settlement, and occupied by fifty soldiers, six civilians, and fifty criminals; but this establishment was finally broken up in June 1856, when the inhabitants of Pitcairn's Island, the descendants of the mutineers of the Bounty, 194 in number, settled on this island. The origin and present condition of this small community are unique. Their whole stock of knowledge and instruction was derived from a common seaman, who was able to read and write, and being in possession of a Bible, undertook to teach the children of the original mutineers, of whom he was the last survivor. These people have thus grown up, living peacefully and happily, in obedience to the precepts of religion, but at the same time destitute, from want of experience, of the knowledge and skill of other civilized communities. They have a magistrate, two councillors, and a chaplain; and they are now under the authority of the governor of New South Wales. They are affectionate, simple, and unsuspicious; but are ignorant of the use of the plough, and of the most necessary trades.

Noricum.

NORICUM, a province of the Roman empire, corresponding to portions of Austria and Bavaria, was bounded

Noris.

on the N. by the Danube, on the W. by Vindelicia and Rhætia, on the S. by Italy and Pannonia, and on the E. by Pannonia. Its name was probably derived from *Noreia*, the ancient capital. It was a mountainous country, traversed by the Alpes Noricæ and other ridges extending from east to west. The valleys between these chains were watered by the Dravus (*Drave*) and other tributaries of the Danube. Yet, on account of the numerous marshes and forests, the soil was not very fertile. The most noted products were mineral. Large quantities of iron were exported to supply the manufactories of arms in Northern Italy, Mœsia, and Pannonia; salt was abundant; and even gold, according to Polybius, as quoted by Strabo, was at one time found.

The country, though alleged to have been for a long time under the government of a king, was divided into several distinct tribes of Celtic origin. Of these the best known were the Norici, who were anciently called the Taurisci; and the Boii, who are said by Cæsar to have emigrated from Boiohemum about 85 B.C. But after the district had been conquered by the generals of Augustus about 13 B.C., the various tribes seem to have lost their individuality, and Noricum itself was reduced into the form of a Roman province. The face of the land also began to assume a new aspect. The fens were drained, the forests were cut down, the climate became milder, and the valleys waved with rich harvests. Several Roman roads traversed the country; and three Roman fleets on the Danube kept back the marauding barbarians of the north. Colonies also were founded, which in course of time became well known under the names of Celeia (*Cilly*), Virunum, Juvavum or Juvavia (*Salzburg*), Lauriacum (*Lorch*), and Boiodurum (*Innstadt*).

NORIS, HENRY, a learned cardinal of the seventeenth century, was born at Verona in 1631. He was carefully educated by his father, Alexander Noris, originally from Ireland, and well known by his *Guerre di Germania*. At fifteen he was admitted as a boarder in the Jesuits' college at Rimini, where he studied philosophy; after which he applied himself to the writings of the fathers of the church, particularly those of St Augustine; and taking the habit in the convent of the Augustinian monks of Rimini, he in a short time distinguished himself amongst that fraternity by his erudition, insomuch that, as soon as he had completed his noviciate, the general of the order sent for him to Rome, to give him an opportunity of improving himself in the more solid branches of learning. His constant course was to study fourteen hours a day; and this he continued till he became a cardinal. He began his *History of Pelagianism* at Rome at the age of twenty-six, and published it at Florence in 1673. To this work he added *An account of the schism of Aquileia, with a vindication of the books written by St Augustine against the Pelagians and Semi-Pelagians*. In the following year the Grand Duke of Tuscany invited him to that city, made him his chaplain, and appointed him professor of ecclesiastical history in the university of Pisa. His History procured the author great reputation, but called forth several antagonists, to whom he published proper answers. The dispute grew warm, and was carried repeatedly before the sovereign tribunal of the Inquisition, where it was examined with the utmost rigour, and the author dismissed without the least censure. In 1692 he was called to Rome by Innocent XII., who made him under-librarian of the Vatican. This post was a step to a cardinal's hat; his accusers therefore took fire afresh, and published several new pieces against him. Noris tried to remove these scruples in a work which appeared in 1695, under the title of *An Historical Dissertation concerning One of the Trinity that suffered in the flesh*. In 1695 his Holiness honoured him with the purple. On the death of Cardinal Casanati in 1700, he was made principal keeper of the Vatican Library. He died at Rome in 1704. His works are characterized by great elegance and erudition; and were published at Verona, in 5 vols. folio, in 1729–30.

Normandy ‖ Norris.

NORMANDY, an ancient province of France, bounded on the N. by the English Channel; E. by Picardy and the Isle of France; S. by Perche, Maine, and Brittany; and W. by the English Channel; had a length of about 150 miles, a breadth of 75, and an area of 10,534 square miles. It now comprises the departments of Seine-Inférieure, Eure, Calvados, Manche, and the greater part of Orne. Its ancient name was *Neustria*; but it was designated Normandy in A.D. 912, when it was conquered by the *Normen* under Rolf, the brother of the first Scandinavian Earl of Orkney.

NORRIS, JOHN, one of the most eminent of the English Platonists, was born at Collingborne-Kingston in Wiltshire, where his father was a clergyman, in 1657. With a view to the clerical profession, he was sent to Winchester school; and at the Michaelmas term of 1676 he entered Exeter College, Oxford. At school he was distinguished for his classical attainments, and at college for his enthusiastic study of philosophy. He soon exhausted the scientific knowledge then current at his university; and eager to explore the fountainhead of that stream of which the waters were so sweet, he began the study of Plato and Aristotle. It was in the groves of the Academy, however, rather than in the halls of the Lyceum, that the young speculator first found what he was in quest of. He graduated as a bachelor in arts in 1680, and having soon after obtained a fellowship in All-Souls' College, he was enabled still farther to indulge his preference for Plato and his divine dialogues. For a temper so melancholy and devout as Norris's seems to have been, the transition from his favourite philosophy to the mystic theology was at once easy and natural; and to heighten the facility still more, he had his attention arrested by the brilliant name of Father Malebranche, a philosopher at once Platonic in temper and Christian in spirit. The *Recherche de la Verité* was then read by all for its lofty eloquence, and studied by the few for the ingenuity of its metaphysics. Norris began an ardent admirer, and ended a zealous disciple of this charming idealist. Meanwhile little was known of this solitary thinker until he inaugurated his career as an author in 1682, in *The Picture of Love Unveiled*, a translation of the well-known *Effigies Amoris* of Robert Waryng. During the same year he published a translation from the Greek of *Hierocles upon the Golden Verses of Pythagoras*, a performance which he followed up by an original work in 1683, entitled *An Idea of Happiness*. Rejecting the common notion of "moral virtue," taught by the Stoics and Peripatetics, as incapable of making men happy in the highest sense, he adopted the more exalted idea of "divine virtue," as inculcated in the writings of Plato and the Pythagoreans. The former regulates the actions of common life; the latter engages in divine meditation and seraphic ecstasy. "He that has only the former," says Norris, "is like Moses, with much difficulty climbing up to the holy mount; but he that has the latter is like the same person conversing with God on the serene top of it, and shining with rays of anticipated glory." This small treatise at once ranked its author with that distinguished band of Platonic divines which adorned the seventeenth century in England. But it was a characteristic of Norris, as of all the thinkers of that devout and learned school, that while intensely fond of speculative retirement, and "happy in leisure and obscurity," as he sings of it, he nevertheless took an active interest in what was passing around him during that noisy and changeful time. The Rye-House plot of 1683 induced him to publish *A Murnival of Knaves, or Whiggism displayed and burlesqued out of countenance*; a performance which showed that its

Norris.

author could discourse of more things than the ecstasies of the mystical union. This sturdy English sense has always proved too much for the full growth and fruition of the higher rhapsodies of mysticism. The political brochure hurled at the Whigs was followed by an attack upon the Calvinistic dissenters, in which the Fellow of All-Souls stanchly combated some of the positions in the theology of the Genevan divine. This tract was entitled *Tractatus adversus Reprobationis Absolutæ Decretum, novo methodo et succinctissimo compendio adornatus, et in duos libros digestus*, 1683. Nor was this the only blow aimed by the sturdy churchman at the dissenters of his day; in 1691 he charged the Nonconformists with schism in a special treatise, after having given them repeated stabs as a sort of by-play in his previous works. Norris obtained his master's degree in 1684, took orders shortly afterwards, and published his *Miscellanies* in prose and verse during the same year. In his poems he endeavours to be something "more than a country fiddler;" aspires "to restore the declining genius of poetry to its primitive and genuine greatness, to wind up the strings of the Muse's lyre," and so forth; and to save his readers from becoming oblivious of his high design, he informs them occasionally, as he proceeds, "this ode is after the Pindaric way." His argument is always high, however; and amidst much purity of sentiment, deep religious fervour, and some tedious moralizing, true gleams of poetry occasionally break forth. This volume was the most popular of all his works, and passed through numerous editions during the author's lifetime. Norris had long been an admiring student of the works of Dr Henry More, then at the height of his newly-won fame as a Platonic mystic, and he resolved now to consult that philosopher respecting some speculative difficulties on which he professed ignorance and curiosity. The correspondence thus begun in 1684 ended only with the death of More three years afterwards, and was published by Norris in 1688. In 1685 he produced a translation of Xenophon's *Cyropædeia* in conjunction with Francis Digby, the latter rendering the first four books, and Norris the remaining four. *The Theory and Regulation of Love* appeared in 1688, in which that Platonic affection of which Norris was so fond finds an ingenious and eloquent advocate. He was made rector of Newton St Loe in Somersetshire in 1689, married during the same year, and gave to the world a treatise on *Reason and Religion*. This was followed, in 1690, by *Reflections upon the Conduct of Human Life*, in a letter to John Locke's friend, the famous Lady Masham. Locke was living with that lady at the time, and on reading Norris's dedication, in which he supposed her to be blind, is said to have "made himself merry withal" at the author's expense. Locke's celebrated *Essay* appeared for the first time during this year, and Norris, whose speculative opinions differed most fundamentally from those of Locke, could not resist the temptation of attaching an Appendix to his *Treatise of Christian Blessedness*, then passing through the press, with "Cursory Reflections upon a Book called *An Essay concerning Human Understanding*." His letter to Lady Masham brought him into collision with the Quakers, in *A Discourse concerning the Grossness of the Quaker's Notion of the Light within*, published in 1692, in which he disabused the minds of that pious sect of the opinion that he was favourable to their views. This treatise is peculiarly valuable, as casting light upon Norris's real relation to mysticism. He had before had occasion to denounce the opinion that all bodily pleasures are to be abjured, and he now insists, with great force and clearness, that "the Quakers represent this light within as a sort of extraordinary inspiration; whereas I suppose it to be a man's natural and ordinary way of understanding." Norris was now presented to the rectory of Bemerton, near Salisbury, where he remained till his death. The revenues of this position were handsome and the work light; and the laborious rector continued to ply his pen with increased ardour. He completed his four volumes of *Practical Discourses* in 1698, and his *Letters concerning the Love of God*, addressed to Mrs Astell, appeared in 1695. The subtle mystical tendencies of the writer's mind come forth in the latter work with peculiar distinctness. He exalts sentiment above science, and feeling above reason. He insists on the absolute exclusiveness of the love of God, and its incompatibility with any possible earthly affection as an end in itself. These opinions he had afterwards occasion to re-assert and vindicate. A very able work from Norris's pen, entitled *An Account of Reason and Faith, in relation to the Mysteries of Christianity*, appeared in 1697, in answer to the *Christianity not Mysterious* of the deistical writer John Toland. Perhaps none of the author's writings would be read with so much interest at the present day as this one. His discussion of the grounds and merits of the rationalism of that period was so thoroughgoing, that the more modern forms of doubt are in a great measure anticipated. None of our modern writers have marked off with a more bold and steady hand the respective provinces of Reason and Faith, whether in the region of natural or supernatural truth. And a truly earnest inquirer, with any adequate appreciation of the real significance of sound speculation, will find more satisfaction in Norris's book—now all but forgotten—than in nine-tenths of all the treatises, pretentious and otherwise, addressed to the thinking public of the present day. The human Reason, according to Norris, is not coextensive with absolute truth, and Faith occupies the border-land between the known and the unknown, the hidden and the revealed. Each faculty has accordingly a legitimate and inalienable sphere of its own, which can only be usurped at the peril of intellectual and moral disorganization. The work, however, by which Norris is best known to the philosophical world is one of less real merit than the former, but occupied with a subject of capital interest to all metaphysicians. He was one of the very first, as has already been observed, to raise his protest against the apparent sensationalism of Locke; and after meditating the subject for seven years, Norris came before the public in 1701 with an elaborate defence of idealism, in *An Essay towards the Theory of the Ideal or Intelligible World*. The second part appeared in 1704. This work is in effect a defence and development of the philosophy of Malebranche, whom Norris styles "the great Galileo of the intellectual world." It displays wide reading and vigorous thinking, and is written in a clear, forcible style. His next work was *A Philosophical Discourse concerning the Natural Immortality of the Soul*, published in 1708, defending that doctrine, with great ability and moderation, against the hostile criticism of Dodwell. With the exception of small treatises on *Humility* (1707) and *Christian Prudence* (1710), and other minor pieces on practical subjects, this work may be regarded as the last of this industrious and able writer. His health, which had never been very robust, ultimately gave way under the ceaseless pressure of active labour; and after lingering for some time, he died at Bemerton in 1711, at the age of fifty-four.

Norristown

NORRISTOWN, a town of the United States of North America, state of Pennsylvania, stands on an elevated spot on the left bank of the Schuylkill, 91 miles E. of Harrisburg, and 17 N.W. of Philadelphia. It is regularly laid out, and well built of stone and brick. There is a handsome court-house, begun in 1851, of light-gray marble; a prison, a bank, a public library, nine or ten churches, and several large boarding-schools. The river, which is here crossed by two bridges, supplies moving power for two large cotton factories and other manufacturing establishments, which employ a great number of hands. The trade of the place is considerable, and is increased by the naviga-

North. tion of the river, and by railways extending to Philadelphia on either side of it. Pop. (1850) 6024.

NORTH, *Sir* DUDLEY, styled by Macaulay "one of the ablest men of his time," was the third surviving son of Lord North, Baron of Kirtling, and was born on the 16th May 1641. He received at Bury and at a writing school in London an education which fitted him for a mercantile life. Being then bound to a Turkey merchant, he was soon afterwards sent out to Smyrna as a factor. The young trader began his career with a scantily-stocked warehouse, but with a determination to make a fortune which might enable him to close his days in ease and luxury at home. Though naturally fond of frolic and pleasure, he kept himself apart from profligate companions, lived with the most careful thrift, and turned all the faculties of his powerful mind upon the duties of his calling. But it was not until in course of time he had been engaged to take the management of an embarrassed factory at Constantinople that he obtained any prospect of success. After collecting the debts of his employer, he established himself in a factory of his own, and began to achieve success by an artful system of policy. He sought the acquaintance of the various foreign ambassadors at Constantinople; he did not hesitate to conciliate the Turks by accommodating his conduct to their superstitions; and he employed all the strategems of trade with an ability which the most wily Jew could not overreach. The result was, that in 1680 the great object of his life had been gained, and he was on his way home to England. Dudley North had not been long settled in London when his profound knowledge both of the theory and practice of commerce was the means of introducing him into public notice. He was advanced to the office of sheriff, and proved himself a most efficient and unscrupulous tool of the dominant Tory faction. His services were rewarded with a knighthood, an alderman's gown, and the post of a commissioner of the customs. Returned to Parliament for Banbury in 1685, he rendered himself unfavourably distinguished by proposing and carrying a tax on sugar and tobacco. But the most permanent cause of his reputation was the publication, in 1691, of his *Discourses on Trade*, a work which is said by Mr M'Culloch to contain "a much more able statement of the true principles of commerce than any that had then appeared." The author died on the 31st December of the same year.

NORTH, *Francis*, Baron Guildford, Lord Keeper of the Great Seal, was the elder brother of the preceding, and was born on the 22d October 1637. From the school of Bury he passed, in 1653, to St John's College, Cambridge, and after studying there for two years as a fellow commoner, he became a member of the Middle Temple. Young North began his legal career with all that concentration of purpose which distinguished his family. His volatile disposition and his passion for pleasure were kept in check; and, setting himself doggedly to the study of law, he endeavoured to subject all his propensities to the calm control of self-interest. The same line of policy was pursued when he had been called to the bar in 1661, and began to travel the circuit. No kind of influence was thought too insignificant to be won. He truckled to the prejudices of the judges; fawned upon those whose hands were full of briefs; and sometimes chose to ride and starve with a certain miserly serjeant named Earl, in order that he might draw from the large experience of his fellow-traveller an account of all the tricks and subtleties of law. By such means the time-serving aspirant soon acquired a proficiency and reputation which combined to lead him on to the highest legal preferments. He was appointed solicitor-general in 1671, attorney-general in 1673, and lord chief justice of the Common Pleas in 1675. At length, in 1682, the Great Seal was intrusted to his keeping. In this high position, where he was the object of general attention, and at this time, when the political world was torn into two factions, North stood prominently out as the most temporizing of the Trimmers. With that low species of tact which cowardice supplies, he shunned every occasion and every company where he might be betrayed into an express statement of his political creed. The letter of the law was the moral code by which he justified his public conduct, and allegiance to the sovereign was the virtue with which he covered his private bearing. It was only when he was sinking into the grave amid general neglect and distrust, that he first showed courage, by warning the infatuated James II. of the ruin towards which the government was tending. His death took place on the 5th September 1685. North.

The Lives of Dudley and Francis North, and of Dr John North, a younger son of the same family, written by their brother Roger North, were published in 2 vols. 4to, 1740–42, and republished in 3 vols., London, 1826. The biographer, although a partial, self-conceited gossip, and a bigoted Tory, unconsciously blabs out now and then many little circumstances which silently cancel his absurd eulogies, and exhibit his heroes in their real characters. (See also Campbell's *Lives of the Chancellors*, and Macaulay's *History of England*.)

NORTH, *Frederick*, Earl of Guildford, the favourite minister of George III., was of the same family as the preceding, and was born on the 13th April 1733. After receiving his education at Eton, and at Trinity College, Oxford, he resided for some time on the Continent preparing himself for his future career. An early entrance into Parliament was followed by a gradual rise through several cabinet offices, until in 1769 he became chancellor of the exchequer, and leader of the House of Commons, under the ministry of the Duke of Grafton. His success in this high position soon proved that he was a proficient in parliamentary strategy. Accordingly, on the resignation in 1770 of the nobleman at the head of the ministry, he was requested to assume the vacant office. The readiness with which North obeyed the request, and relieved the embarrassed mind of the king, made him a great favourite with George III., as he was already with the House of Commons. Yet the administration so auspiciously begun soon became remarkable for the calamities it brought upon the nation, and the strong and malignant opposition it excited. The refusal of the ministry to relieve the American colonists from the paltry duty on tea, led to disturbances in 1773 which issued in open rebellion in 1775. Then the Whig Opposition, led on by Burke and Fox, commenced a series of the most virulent attacks that had ever been witnessed in the British senate-house. Not content with execrating the public policy of the minister, they blackened his private character, cast taunts upon his capacity, raked up every family scandal, and even clamoured for his head. The Parliament hall resounded with the most confused and boisterous wrangling. Yet on many a stormy night Lord North fought almost single-handed against his great adversaries, meeting their bold measures with his consummate tact, counteracting the effect of their grand rhetorical displays with his strong common sense, and blunting the edge of their satire with his pungent wit and imperturbable good humour. For six years he thus kept his ground triumphantly. By that time, however, affairs were beginning to draw towards a crisis. The British were shamefully failing in their attempts to suppress the Americans; France and Spain had espoused the cause of the colonists; the public were waxing loud in their indignation against the ministry; and in 1781 William Pitt, entering Parliament, consummated the oratorical strength of the Opposition. Lord North, though he still held his original opinion regarding the justice of the American war, would then willingly have resigned. But he was repeatedly induced

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by the opinionative king to pursue, in opposition to his inclination, that administration which was endangering the safety of the country. At length, in 1782, he was forced to give place to Lord Rockingham. The rest of the parliamentary career of Lord North did not retrieve his political reputation. Though the celebrated coalition which he formed with Fox overthrew the ministry of Lord Shelburne and Pitt, and raised him in 1783 to the post of secretary of state under the Duke of Portland, yet it became universally unpopular, and did not keep him in power for more than six months. This was the last time that North was in office. He died in 1792, five years after he had been struck with blindness, and two years after he had succeeded to the family estates and to the title of the Earl of Guildford. (For fuller information regarding the administration of Lord North, see BRITAIN. See also Lord Brougham's *Statesmen of the Time of George III.*)

NORTHALLERTON, a parliamentary borough and market-town of England, capital of the North Riding of Yorkshire, on an affluent of the Whisk, 32 miles N.N.W. of York, and 225 N.N.W. of London. It consists of a principal street, broad and well paved, and numerous lanes diverging from it. The parish church is large, in the form of a cross, and has a square tower at the west end. There are also chapels belonging to Independents, Wesleyans, and Primitive Methodists, Baptists, and Quakers; and several schools and charitable institutions. One of the latter, called the Maison Dieu, was founded in 1476, and has since been rebuilt. Northallerton has a market-house near the centre of the town, a jail built after the plan of Howard, and a court-house. There are here flour-mills, tanneries, brick-kilns, breweries, malt-houses, and other manufactories. The market-day is Wednesday; and five yearly fairs are held. In the neighbourhood of the town is a place called Standard Hill, where was fought, in 1138, the battle of the Standard, in which King David of Scotland was defeated by the English. The borough of Northallerton returns one member to Parliament. Pop. (1851) 4995.

NORTHAMPTON, a parliamentary and municipal borough and market-town of England, standing on the north side of the River Nen or Nene, is probably the *Antona* of Tacitus (*Annal.* xii. 31); Lat. 52. 15. N., Long. 0. 55. W., 67½ miles from London by the London and North-Western Railway. It is a place of great antiquity, and supposed to have been of British origin; but the earliest mention of it is in the Saxon Chronicle, under the name of *Hampton:* in *Domesday Book* it is called *Northantone.* The castle, of which only some small portion of the walls and an arch of semi-Norman character remain, was built by Simon de St Liz, to whom William the Conqueror had given the town with the hundred of Fawsly. Several Parliaments were held here; the first of these in 1130–31, in the thirty-first year of Henry I.; and the last, in the fourth of Richard II. (1380), being that which originated the poll-tax that occasioned the rebellion of Wat Tyler and Jack Straw. From its central situation, the town or its neighbourhood was frequently the scene of conflict during the civil wars both of earlier and later date. On July 10, 1460, a battle was fought here between Henry VI. and the Yorkists, &c., when the former was defeated, and brought a prisoner into the town. In 1642 Northampton received a garrison for the Parliament under Lord Brooke. On March 30, 1645, Cromwell marched from it with 1500 horse and two regiments of foot to Rugby. After the Restoration, October 17, 1661, the walls of Northampton, with those of Coventry, Leicester, Gloucester, and Taunton, were demolished, these towns having taken the side of the Parliament. In 1675 the town was almost destroyed by a fire in the short space of six hours; L.25,000 was collected by briefs and private charity towards repairing the damage. Charles II. gave 1000 tons of timber from Whittlewood Forest towards rebuilding All Saints' church, and remitted the duty of chimney-money for seven years. In 1720 it was damaged by an extraordinary flood. In 1750 a violent shock of an earthquake was felt, which lasted nearly a minute; and in 1776 another of shorter duration. Northampton.

The town is pleasantly situated on an eminence sloping to the south. Its general appearance is neat and clean. The older buildings are constructed of a brownish-yellow stone found in the neighbourhood, being the inferior oolite; the modern houses are chiefly of brick or of a white stone (the great oolite) from quarries in the adjacent village of Kingsthorpe. The general style of architecture has nothing remarkable: numerous alterations of late years have been going on, chiefly in making more showy frontages to the shops. The market-square is one of the largest in the country, being about 600 feet square. For the last twenty years the town has been rapidly extending, especially towards the N. and E.: on the outskirts a great number of new streets have been built, consisting of neat tenements adapted to the working-classes, which form a pleasing contrast to those built at the commencement of the century. On the eastern side houses and villas of a more imposing aspect have been erected for the use of the gentry and more opulent tradesmen. The streets in general are well paved, and lighted with gas.

Of the public buildings, the principal are—the general infirmary, established in 1747; the present building was erected in 1793, and affords accommodation for about 120 patients. It has a medical library of 3000 volumes, and a splendid collection of anatomical casts, which are deposited in a separate building, containing also a convalescent ward for ten male and ten female patients. The general lunatic asylum, about half a mile from the town in the same direction as the infirmary, was opened in 1838, and by subsequent enlargements is able at the present time (1858) to receive about 280 patients. It is a self-supporting institution. The Royal Victoria Dispensary, established in 1844 to commemorate the visit of her present Majesty to the town, is conducted on the provident principle, every member above the age of fourteen subscribing one penny per week: twopence a week will admit a man and his wife and all his children under fourteen years old. The union workhouse, on the Wellingborough road, has accommodation for 300 inmates. The county-hall, where the quarter sessions, the assizes, and county courts are held, is a good specimen of Italian architecture, contemporary with the later features of All Saints' church. The town-hall is an ancient building, and retains a good deal of carved panelling from the time of Henry VII. to that of Elizabeth. Forty or fifty years ago alterations were made which diminished the original capacity of the principal storey; and the external staircase, which previously existed, was removed, and one within the building substituted. As it now stands, it is very inadequate to the wants of the town. The corn exchange, erected a few years ago, consists of one large hall, the interior of which has an imposing effect; it is frequently used for musical performances, and has an excellent organ; attached to it are the offices of the mechanics' institute, which has a library of nearly 11,000 volumes, and now enrols 600 members. The Religious and Useful Knowledge Society, supported principally by members of the Established Church, occupies a building in another part of the town. It has about 1000 members.

The town has seven churches—All Saints', St Sepulchre's, St Peter's, St Andrew's, St Katherine's, and St Edmund's. The last three are of recent date. The old church of All Saints, which was considerably larger than its successor, was destroyed by the great fire of 1675; but the tower escaped, and was incorporated with the new

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structure. Its style is the decorated, and the additions, in defiance of all congruity, are in that Italian style which Inigo Jones and Wren had rendered fashionable, and, as such, have great merit. The interior of the church is strikingly beautiful. It contains a statue, by Chantrey, of Spencer Percival, many years a member for the borough. At the western entrance a portico extends the whole width of the church, consisting of twelve Ionic pillars supporting an entablature and balustrades. A statue of King Charles II. surmounts the centre; he is represented in Roman costume, with a truncheon in his hand, and his head covered with a wig of ample curls. St Peter's is a most interesting specimen of early and richly-ornamented Norman work. The capitals of the columns of the nave are charged with curious sculptures in a high state of preservation. The tower arch also is elaborate, with chevron mouldings; and some pilaster columns, on each side, are richly ornamented. Externally, also, the church has many interesting features; the tower especially, which has buttresses of three semi-columns diminishing at each storey. St Sepulchre's has a special interest as one of the four existing round churches built after the model of the Holy Sepulchre at Jerusalem. It bears evidence of having been erected at periods widely different: the circular part is Norman and early English; the spire, a fine piece of work, is perpendicular. St Giles' has a good Norman door at the western entrance, and the tower arch is of the same period.

Of the places of worship belonging to the various nonconformist bodies, four belong to the Baptists; five to the Wesleyan, Primitive, and Associated Methodists; three to the Independents; the Unitarians, Quakers, and Roman Catholics have one each. In Castle Hill Chapel, a mural tablet is erected to the memory of Dr Doddridge, who exercised his ministry there for upwards of twenty years. A similar memorial is erected in the Baptist chapel in College Street to the memory of the Rev. John Ryland, who was minister there for thirty years, and was succeeded by his son, the late Dr Ryland, afterwards president of the Bristol Baptist College.

St John's Hospital, in Bridge Street, is a very ancient, and was at some period a very wealthy foundation. Its available revenues are now equal only to the maintenance of a certain number of aged women, some of whom have rooms in the building. The importance of the charity in early times is evident from the architectural features of the hospital still remaining. St Thomas's Hospital was founded in 1450, in honour of St Thomas à Becket. It was first endowed for twelve poor widows; to these six were added by Sir John Langham in 1684, and since then the numbers have been still further increased.

In Marefare is the free grammar school, founded in 1556 by Thomas Chipsey, a grocer of the town. Dr Thomas Cartwright, Bishop of Chester, and James Hervey, the author of the *Meditations* and other works, were educated here. A free school, called the Blue-Coat School, was founded in 1700. There are also various parochial schools, and an excellent British school for boys and girls. The Sunday schools belonging to the Established Church and the different bodies of dissenters are numerous.

The town is divided into three wards—east, west, and south; and is governed by a mayor, six aldermen, and eighteen councillors; besides nine justices of the peace, a recorder, and town-clerk. The borough has sent two members to Parliament from the commencement of the reign of Edward I.

The coach-road to the metropolis, through Newport-Pagnell, Woburn, Dunstable, St Albans, and Barnet, has been superseded by the London and North-Western Railway, which is connected with Northampton by means of a branch line from Blisworth, making the distance 67½ miles. From Northampton the railway has been carried eastward to Peterborough, and a line, entering the town at the West Bridge, is also now in progress from Market-Harborough, where it will join the line from Leicester to Hitchin. Before the formation of railways, coals and heavy goods were brought to Northampton by means of the Nen and a branch canal from the Grand Junction at Blisworth. Markets for the supply of meat and vegetables are kept on Wednesdays and Saturdays; the latter is also a cattle-market. About twelve fairs are held in the course of the year. That on September 19 is called the "cheese fair." The wool fair is held in the first week in July. The race-course is 117 acres in extent. The Northampton and Pytchley Hunt races are held in March, at the close of the hunting season.

The barracks were finished in 1796 for the accommodation of cavalry, and are situated at a short distance from the race-course.

The borough gaol was opened in 1846. It is constructed on the separate system, and is capable of containing eighty persons. The county gaol was opened in the same year, and is capable of receiving 150 prisoners. About a mile S. of the town, on the old London road, is one of the crosses erected by Edward I. to the memory of his queen, Eleanor of Navarre. It is a work of great beauty, and in fair preservation, but the upper portion has long been wanting, and no record remains of its character. An entry in the expense rolls makes mention of five images, and it has been conjectured that the fifth (only four being required for the canopy) surmounted the monument.

The staple manufactory of the town is that of shoes, in which the great majority of the working-classes are engaged. A large proportion of the army contracts are executed here and in the adjacent town of Wellingborough. Stockings were formerly made here; and the first stocking-frame used in Leicester was brought to that town in 1680 by a person from Northampton named Alsop. Lace-making also was carried on to some extent, but it has almost entirely ceased. There are three extensive iron-foundries in Northampton. At Rushmills, about 2 miles from the town, is a paper manufactory which supplies the bank-note paper and the stamps for postage. The population has rapidly increased during the last fifty years. In 1801 it amounted to 7220; in 1811 to 8427; in 1821 to 10,844; in 1831 to 15,351; in 1841 to 21,242; and in 1851 to 26,657. (J. E. R.)

NORTHAMPTON, a post-town and shire-town of Hampshire county, Massachusetts, one of the United States of North America. It stands on a hill near the west bank of the Connecticut River, 95 miles W. from Boston; and consists chiefly of two streets laid out with considerable regularity. It contains several handsome public buildings, of which the court-house, jail, and one of the churches are the most conspicuous. The private houses are in general large and in a good style, and many of them are elegant. Northampton is one of the most beautiful towns in New England, and distinguished for the refinement and intelligence of its inhabitants. A stream passes near the centre of the town, on which are erected numerous mills and many manufactories. The rearing of the silk-worm has been carried on here for some time, and large quantities of silk, as well as cotton and woollen goods, are manufactured. Farmington Canal extends from Newhaven to this place. A bridge, built in 1826, connecting this town and Hadley, is 1086 feet in length by 36 in breadth, and is supported by six piers and two abutments. The lands bordering on Connecticut River, in which are now the towns of Northampton, Hadley, and Hatfield, were first known by the Indian name *Nonotuck*. It was the third place settled on the river in this state, and was incorporated in 1654. Amongst the striking objects in the scenery of Northampton are the

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beautiful river, and the heights called Mount Tom and Mount Holyoke, the former being 1200 and the latter 900 feet above the river. Long. 72. 38. W., Lat. 42. 19. N. Pop. (1850) 5278.

NORTHAMPTONSHIRE, one of the midland counties of England, bounded by a greater number of counties than any other like division of England, having on the N. the counties of Leicester, Rutland, and Lincoln; E. those of Cambridge, Huntingdon, and Bedford; S. those of Buckingham and Oxford; and W. Warwickshire. It lies between 51. 59. and 52. 40. N. Lat., and 0. 8. and 1. 20. W. Long. It is about 66 miles in length; the breadth in the widest part is 26 miles, in the narrowest not more than 8 miles. Its extent is 630,358 acres, of which probably 580,000 are arable, pasture, and meadow land. In 1841 the population was 139,228; in 1851 it had increased to 212,380, occupying 43,942 houses.

In ancient British times this county was the most southern part of the Coritani; by the Romans it was included in the province of Flavia Cæsariensis. The Roman roads Watling Street and Ermine pass through it; the former on the S.W. from Towcester to Lilbourne, the latter enters by Castor, and branches off at Upton. In the Saxon period this county made part of the kingdom of Mercia. It suffered repeatedly and severely from the incursions of the Danes. Simon De St Liz, a follower of William the Conqueror, having received from his sovereign the town of Northampton to find shoes for his horses, fortified it, and built the castle at the west entrance. During the 12th century many councils were held at Northampton. The battle which decided the fate of Charles I. was fought at Naseby, June 14, 1645. Besides an obelisk erected a mile to the east of the scene of action, the "Sulby hedges" still remain as a more exact landmark.

The whole of the county is within the diocese of Peterborough, with the exception of three parishes, Gretton, Nassington, and King's Sutton, which are in the diocese of Lincoln. It forms an archdeaconry, containing 293 parishes, of which 172 are rectories, 93 vicarages, and 29 perpetual curacies.

From the census of 1851, it appears that in this county there were at that time 592 places of worship, having in all 151,687 sittings. Of these, 292 places of worship belonged to the Episcopalians, 122 to various bodies of Methodists, 87 to Baptists, 56 to Independents, 6 to Quakers, 6 to Roman Catholics, 4 to Latter-day Saints, 3 to Moravians, and 16 to other bodies. The number of Sunday-schools was 426, with 33,614 scholars. Of the former, 257 belonged to the Episcopalians, 68 to Methodists, 52 to Baptists, and 39 to Independents. Of day-schools there were 276 public, with 18,969 scholars; and 411 private, with 7555 scholars. Of the public schools, 169 were supported by religious bodies, 88 by endowments, and 14 by general or local taxation. There were also 15 evening schools for adults, and 8 literary and scientific institutions.

By the Reform Bill the county was divided into two divisions, N. and S., each containing ten hundreds, and returning two members. The election for the northern division is held at Kettering, and the polling-places are Kettering, Peterborough, Oundle, Wellingborough, and Clipstone. The election for the southern is held at Northampton, and the other polling-places are Daventry, Towcester, and Brackley. Two members are also returned for Peterborough, and two for Northampton.

This county, although destitute of any bold or striking scenery, presents an agreeable variety of hill and dale, bearing those marks of cultivation which indicate industry and comfort on the part of the occupiers. The general elevation of the land is about 300 feet above the level of the sea; and the highest point, Arbury Hill, in the neighbourhood of Daventry, rises only to the height of 804 feet above sea-level. Owing to this absence of elevations, and to the inland position of the county, it is less subject to heavy and continued rains than most parts of England. The climate is mild and salubrious; and the soil is generally rich and fertile. It is pretty equally divided for the purposes of tillage and grazing. Some of the farmers are great cattle-breeders, but the majority purchase beasts to fatten them for the market. Another agreeable feature is the great number of noblemen's seats, and the mansions of the gentry, with the parks and plantations that adorn them. The woodlands are extensive, consisting chiefly of the remains of the royal forests of Rockingham, Salcey, and Whittlebury, with the chases of Geddington and Yardley. The ash is the staple timber tree of the county, and fetches a high price.

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The county is not remarkable for mineral productions. Limestone is abundant, and within the last few years the soil has been worked for ironstone in the neighbourhood of Northampton and along the line of the Peterborough Railway, and has been found to yield a tolerably large percentage. Good clay for bricks and tiles is to be met with in many parts: there are also quarries for roofing-flags.

The only navigable river in this county is the Nen, or Nene. It rises in the western part, flows across the county, and then runs N. till it enters the German Ocean by Lincolnshire. The Welland rises at Sibbertoft, and forms a boundary between the county and Leicestershire and Rutland. The other rivers, the Ouse, the Avon, the Severn, and the Charwell, which, like the two former, have their sources in Northamptonshire, are but inconsiderable rivulets till they enter the adjoining counties. Previous to the construction of railways the canals were important aids to inland traffic. The Oxford Canal connects the county with that city. The Grand Junction Canal, communicating on the one hand with London, and on the other with Liverpool and Manchester, passes through the county, and is navigable for barges of 60 tons burden. The Grand Union Canal connects it with Leicester.

At the period of the Reformation the number of religious houses, including colleges and hospitals, amounted to nearly sixty. Of the great abbeys, Peterborough is the only one that has been preserved entire; to which may be added the collegiate churches of Fotheringay, Higham-Ferrers, and Irthlingborough. The principal monastic remains are to be found at Daventry, Canons' Ashby, and Dingley. The county is rich in almost every style of ecclesiastical architecture. As specimens of the early Norman style may be mentioned the churches at Earl's Barton, Barnack, Brixworth, Brigstock, Castor, Spratton, Barnwell, and Twywell. Of ancient mansions the most deserving of notice are Castle-Ashby, the seat of the Marquis of Northampton, of which the oldest part was built in the reign of Henry VIII.; and Burghley House, near Stamford, built by Queen Elizabeth's lord treasurer, and now the seat of the Marquis of Exeter. Kirby Hall, near Rockingham, built by Sir Christopher Hatton, is now falling rapidly to decay, though habitable within the last half century. Althorpe, the seat of Earl Spencer, of uncertain date, but restored by the Earl of Sunderland in 1688, claims notice for its magnificent library, formed principally by the grandfather of the present Earl (1858), being the richest in early printed works of any private collection in the world. Of the crosses erected by Edward I. in memory of his queen Eleanor which still remain, two out of three are in this county—one at Hardingstone, near Northampton, and the other at Geddington.

Of celebrated persons, who were natives of this county or connected with it, the following may be mentioned:—Robert Brown, founder of the sect of the Independents, born at Tolthorp, in Rutlandshire; John Dryden and Thomas Fuller, born at Aldwinckle; James Hervey, author of the *Meditations*, born at Hardingstone, and died at

North Cape || Northcote.

Weston Favell; Bishop Wilkins; William Law, author of *The Serious Call*, born at King's Cliffe; Dr Doddridge, born in London, but resident at Northampton, minister of the Castle-Hill Meeting-House, and tutor of the Dissenting Academy in that town; Parkhurst, the biblical lexicographer; Dr Paley; and Dr Carey, the missionary and oriental scholar, born at Paulerspury. Two of America's greatest sons were connected with this county. Franklin's ancestors had a freehold estate of about 30 acres for at least 300 years at Ecton, five miles from Northampton, where they carried on the trade of blacksmiths. General Washington was the great-grandson of John Washington, of Sulgrave, who emigrated to America in 1637, and whose great-grandfather, Lawrence Washington, was mayor of Northampton in 1532 and 1548. At Northborough Oliver Cromwell's wife died, and his favourite daughter, Elizabeth, married Sir John Claypole, the lord of the manor, the chapel of whose family remains attached to the parish church. At Abington, Shakspeare's favourite grand-daughter, who married Sir John Bernard, lived and lies buried there. It would be unpardonable to omit the name of the late George Baker, whose *History and Antiquities* of the county form a monument of the indefatigable researches and minute accuracy of the author; and which his sister, Miss Baker, his faithful companion and fellow-labourer, by her ample *Glossary of Northamptonshire* (London, 1854) has made a lasting contribution to the history of our language. (J. E. R.)

NORTH CAPE, the most northerly point of Europe, is situated in the island of Mageröe, separated from Norway by a narrow strait; N. Lat. 71. 10., E. Long. 25. 46. It consists of a long range of steep rocks, about three-quarters of a mile broad, and 1200 feet above the sea. The geological structure of these rocks consists of gneiss, quartz, and other primary formations. On the E. side there is a small bay, hollowed out of the rock, which affords a landing-place; but at all other parts it is inaccessible from the sea.

NORTHCOTE, James, an eminent English painter and writer on art, was the son of a poor watchmaker, and was born at Plymouth on the 22d October 1746. After receiving a scanty education, he was apprenticed at an early age to the trade of his father. He soon betrayed a decided love for painting, however, and some humble successes in portraiture induced him, after he had reached his twenty-first year, to abandon watchmaking, and to set up a small studio in his father's house. The chief event which determined the success of his after career was his introduction to Sir Joshua Reynolds in 1771, who received the young aspirant into his own house as one of his pupils. Northcote now entered upon a course of regular study, with an untiring enthusiasm which secured the approval and lasting kindness of his master. Late and early he was found either in the gallery of Sir Joshua or in the Royal Academy. At the expiry of his term of five years, the desire to look upon the great paintings of Italy occupied his mind. During the next year he plied his pencil in order to obtain money for his travelling expenses; and in 1777 he repaired to Rome, with a scanty purse and with no knowledge of any language except his own. It was his purpose to make portraitures the staple of his support, and to devote his leisure moments to the higher and more congenial subjects of historical painting. Accordingly, during his sojourn of three years in Italy, the works of Titian and Michael Angelo were the chief objects of his study; and he flattered himself that he had caught the grand style of these great masters. Yet no sooner had he been removed from the daily inspection of Italian art, than he slid insensibly into an imitation of Sir Joshua Reynolds.

On his return to London in 1780, Northcote became a professional painter of portraits and history. An air of propriety pervaded whatever he executed; his colouring, somewhat dull, and his drawing, stiff and defective, were redeemed by a certain academic grace; and although he lacked the highest gift of an historical artist—the power of conceiving an entire scene in all its details—his knowledge of what a picture ought to be enabled him, after much careful correction and elaboration, to portray an event with feeling and clearness. A love of money combined with a love of art to keep him constantly before his easel. If his merits were not always recognised, it was not because he was too modest to display and avow them; and if his rivals sometimes threw him into the shade, it was because his contemptuous taunts and depreciating criticism failed to prevent them from rising. His services were soon hired by Alderman Boydell, a munificent patron of the fine arts, and the originator of "The Shakspeare Gallery." Northcote was thus enabled to concentrate all his attention upon that branch of the art most congenial to his taste. The first paintings that he executed for his employer were, "The Murder of the Royal Children in the Tower," "The Death of Wat Tyler," and "Arthur and Hubert;" and these at once established his reputation. The Royal Academy elected him a member in 1787, and he was welcomed into his seat by the president, his kind old master, Sir Joshua. Although, in a short time afterwards, the failure of Boydell threw him back upon portraiture, his fortunes did not cease to rise. Numerous sitters flocked to his studio; commissions for poetical and historical pieces occasionally dropped in; and in 1791 his earnings, which had been hoarded up with the utmost care, were fast swelling into a handsome competence. His fame, however, began to decline; his portraits could not stand comparison with the masterpieces of Lawrence, which were now beginning to come into the field; and all his open depreciation of his young rival could not prevent the public from thinking so. He tried moral painting in 1796, in the "Modest Girl" and the "Wanton," but found he could not compete with Hogarth. Falling back upon history, he produced "The Earl of Argyll in Prison," and "The Vulture and Snake." But the golden age of historical painting was passing away, and his own hand, weakened by age, was gradually forgetting its cunning. Last of all, he tried book-making, and in 1813 published a life of Sir Joshua Reynolds, which was chiefly valued on account of the sayings and anecdotes which it preserved. It was while the reputation of Northcote had thus failed to be sustained by himself, that it was revived by his newly-acquired friend, the celebrated William Hazlitt. The two acquaintances had frequent intercourse; the painter vented his pungent remarks and cutting gibes while his hand plied the brush mechanically, and the writer noted down the conversation as it proceeded. The result was, that the sayings of Northcote were published by Hazlitt in periodical sections in the *New Monthly Magazine*, under the title of *Boswell Redivivus*. The popularity which that series of papers secured confirmed the bond between the chronicler and his hero. A large work in 2 vols. 8vo, entitled *Titian and his Times*, was thus produced between the two in 1830. This was the last effort of Northcote. He died on the 13th July 1831. (Cunningham's *Lives of Painters*, &c.)

Northern Circars || North Sea.

NORTHERN CIRCARS. See Circars, *Northern*.

NORTH SEA, or German Ocean, a part of the Atlantic Ocean, lying between Great Britain on the W. and Denmark and Norway on the E.; extends from N. Lat. 51. to 61., E. Long. 2. 30. to 7. 30. Its length is about 700 miles, its breadth about 420 miles, and its area about 270,000 square miles. Near the coasts of Norway, which are steep, and, though indented by deep fiords, send but few streams to the sea, the depth is the greatest, being about 190 fathoms; while the average depth of the whole sea is only 31. On the low southern shores the Elbe, Weser, Rhine, and Scheldt, which here discharge themselves, have

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carried down immense quantities of sand, which have made the southern portions of the sea comparatively shallow; while on the coast of Great Britain the same effect, though to a less extent, has been produced by the Thames, the Ouse, the Humber, the Tyne, the Forth, and the Tay. The centre of the sea is occupied by several large sand-banks, the principal of which are, one extending from the Firth of Forth 110 miles to the N.E., another stretching nearly as far N.W. from the mouth of the Elbe, and the Dogger Bank, which lies between N. Lat. 54. 10. and 57. 24., E. Long. 1. to 6. 7. The North Sea has also some remarkable deep holes, such as the Little Silver Pit, off the Yorkshire coast, the Great Silver Pit, and the North North-East Hole. The sea abounds in fish, especially cod, hake, ling, turbot, soles, mackerel, herring, &c.; and fishing is extensively carried on, both on the different shores of the sea, and on the Dogger Bank, where cod is obtained. The tides in this sea are formed by the great wave of the Atlantic which passes round the S. and N. of the British Islands. The tide-waves from the N. and S. meet on the coasts of Jutland, where the tides nearly neutralize each other. On entering the North Sea the height of the wave is about 12 feet; but the form of the shore, the nature of the bottom, and the direction in which it meets the land, cause it to vary somewhat in height at different places, and on the Humber it rises to 20 feet. The islands in this sea are of insignificant size, and are three in number—Heligoland, off the Elbe; the Isle of May and the Bell Rock, in the Firth of Forth. On all these, and on many other points, light-houses have been erected. The North Sea is connected with the English Channel by the Straits of Dover, and with the Baltic by the Skagerrack, the Cattegat, the Great Belt, the Little Belt, and the Sound.

NORTHUMBERLAND, an extensive county in England, situated on its northern extremity, upon the borders of Scotland, from which it is separated partly by the River Tweed, which, during the latter part of its course, flows between this county and Berwickshire, and partly by a line supposed to be drawn over the mountainous region on the W. and N.W., where it meets with Roxburghshire. The other boundaries are the German Ocean on the E., Durham on the S., and Cumberland on the W. On the N. are two small districts called Norhamshire and Islandshire, which, though belonging by their situation to Northumberland, formed a part of the county of Durham, along with another tract called Bedlingtonshire, on the S.E. By a recent act of Parliament these have been united to Northumberland, and the Tweed has thus become the northern boundary of the county. The town of Berwick, also on the N. of the Tweed, has been added to Northumberland for election purposes, but has still a separate jurisdiction, with a sheriff of its own. Lindisfarne, or Holy Island, on the N.E. coast, which in like manner belonged to Durham, is situated about two miles from the mainland, opposite to the mouth of the brook Lindis, and accessible to all kinds of conveyance at low-water. Although about nine miles in circuit, it contains little more than 1000 acres, the half of which is sand-banks. In this view, Northumberland is situated between 54. 48. and 55. 42. N. Lat., and between 1. 25. and 2. 41. W. Long. Its greatest extent from N. to S. is 64 miles, and from E. to W. it varies from about 46 miles, which is its usual breadth between the River Tyne on the S. and the Coquet on the N., till it terminates at the town of Berwick on the N., in a breadth of only 5 or 6 miles. The area is 1952 square miles, or 1,249,299 acres. Nearly one-third of the county is scarcely capable of beneficial cultivation.

It is divided into six wards, namely, Tyndale, Coquetdale, Glendale, Bamborough, Morpeth, and Castle; the first three comprising the western and mountainous district, and the second three the coast lands on the E. Besides these, Northumberland includes the county of Newcastle. The maritime wards, though extending over only one-fourth of the county, are by far the most wealthy and populous, owing chiefly to the great coal-works in Castle ward, near the town of Newcastle, and along the banks of the Tyne. It contains five deaneries and seventy-three parishes, all of which are in the archdeaconry of Northumberland and diocese of Durham.

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All the western side of this county is mountainous, from the boundary of Durham on the S. almost to the valley of the Tweed on the N.; but this extensive tract, comprising more than a third of the whole area, is not all of the same character. The northern, or Cheviot Hills, extending to about 90,000 acres, being for the most part green nearly to their summits, comprehending many narrow but fertile glens, and affording excellent pastures for the breed of sheep to which they have given their name; whilst those to the W. and S. are, in general, open solitary wastes, covered with heath, and of very little value. Along the coast, from the mouth of the Tyne to that of the Tweed, the country is, with few exceptions, level and rich, with a soil which, in some places, is a strong clay, and in others a dry loam, but almost everywhere very productive, under the enlightened system of cultivation which prevails so generally throughout Northumberland. The climate of Northumberland is colder, and the time of harvest later, than in the more southerly parts of England. The western and upland regions are cold and bleak; but near the sea, although chill east winds sometimes prevail, the temperature is considerably milder and warmer. The coast is generally low, and has numerous bays and headlands; while near to the mainland there are several small islands which are included in the county.

The principal rivers of the county are the Tyne, Blyth, Wansbeck, Coquet, Aln, and the Tweed, all of which fall into the sea, carrying with them the tribute of many smaller streams. The Till, which empties itself into the Tweed, is also a considerable rivulet. The Tyne and the Tweed are by far the most important, the tide flowing up the former 16 miles, and up the latter 8 or 10 miles; whilst the navigation of the other rivers is confined to a small distance from their mouths. Both of these have long been celebrated for their salmon fisheries, which are, however, much less productive than formerly. Those on the Tyne barely supply the local consumption, but the Tweed fisheries afford a valuable article of trade with London, to which the fish are sent packed in pounded ice, by which means they are presented in the market in nearly as fresh a state as if they had been newly taken from the water.

Northumberland has long been distinguished for its subterranean treasures, which are the main source of its wealth and cause of its populousness. Of these, coal, which abounds in most parts of it, is by far the most important. It is of the best quality in the south-eastern quarter, on the banks of the Tyne, whence those vast quantities are exported which supply the great consumption of the metropolis, as well as other British and foreign ports. The coal is all of the kind called "caking coal," which melts and runs together in the fire, and, when of the best quality, leaves very little ashes. Calculations have been made as to the extent of this tract, the quantity of coal which it may contain, and the period when it must be exhausted; but upon this latter point there is a great difference of opinion, some estimating that the supplies must cease in three hundred years, some not in less than eight hundred, whilst by others it is held to be almost inexhaustible. Of the coal found in Bamborough, Islandshire, and Glendale ward, the seams are in general thin, and the quality inferior, not caking nor burning to a cinder, but yielding a great quantity of ashes. This is used only for home consumption and for burning limestone, a purpose for which it is well adapted. Through

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all this district coal and lime are generally found together: but the south-eastern quarter, which is so rich in coal, is destitute of limestone. Lead ore abounds in the mountains on the S.W., particularly towards the head of that branch of South Tyne called Allendale, where it has long been wrought to a considerable extent. Iron ore is found in many parts; stone marl near Tweedside, shell marl in Glendale ward, and various sorts of sandstone or freestone are obtained in almost every quarter, some of it affording tolerable flags for roofing and for floors. In the sandstone quarries excellent grindstones are obtained, and a great many are exported.

The agriculture of Northumberland is an object which is only second in interest and importance to its coal-works. Almost all those branches of rural economy for one or more of which other districts are celebrated, may here be found combined into one system, and conducted upon the same farms. One finds here, in great perfection, the Leicester and Southdown sheep and the short-horned cattle of Durham and Yorkshire; the turnips of Norfolk, cultivated upon the drill system of Scotland; the well-dressed fallows of East Lothian and Berwickshire; and that regular alternation of tillage and grazing which is, of all other courses of cropping, the one best adapted to sustain, and even to improve, the productiveness of the soil. These remarks apply in an especial manner to the northern part of the county, where the farms are in general large, and the occupiers men of education and liberal acquirements. This quarter has been long distinguished as a school of agriculture, to which pupils are sent, some of them gentlemen of fortune, from various parts. The common period of leases, at least in the northern district, is twenty-one years, although many are shorter, and upon a few estates no leases are granted. By the account taken for the purpose of levying the property-tax in the year 1843, it was found that the annual value of the real property amounted to L.1,542,434. It may be worthy of remark here, that at the seat of the Earl of Tankerville, called Chillingham Castle, there still exist in the forest some remains of the herds of wild cattle which are supposed to have formerly abounded in this island, and to have been the origin of our race of cows.

This county is traversed by two principal lines of railway, extending from Newcastle, the one northwards along the coast to Berwick, and the other westwards to Carlisle. The length of the former, which is entirely in Northumberland, is 66 miles, while the latter extends 41 miles before it leaves the county. There are also shorter lines connecting Newcastle with North Shields, Tynemouth, and Blyth.

Northumberland is not eminently a manufacturing county. Some wool-combing is carried on at Hexham, and some thread is spun in the villages; but the chief branches of manufacturing industry are those that depend upon the collieries, and are chiefly carried on within and around the town of Newcastle, to which head in this work the reader is referred.

Of all the English counties none is so rich as this in remains of the Roman era. Among these, the most important is the famous wall built by Agricola against the Picts, and subsequently repaired and improved by Hadrian and Severus. It extends across the S. of the county from the Tyne to the Solway Firth. There is a great Roman road running northwards through Northumberland into Scotland; and there are, besides, many Roman camps and stations.

The population of the county at the six decennial enumerations has been as follows:—In 1801 it amounted to 168,078, in 1811 to 183,269, in 1821 to 212,589, in 1831 to 236,959, in 1841 to 266,020, and in 1851 to 303,568. The number of inhabited houses in 1851 was 47,737. Northumberland contained, in 1851, 488 churches, with 136,066 sittings. Of these, 154 belonged to the Church of England, 198 to Methodist sects, 68 to Presbyterians, 20 to Roman Catholics, and 14 to Independents. There were also 359 Sunday schools—131 Episcopalian, 115 Methodist, 55 Presbyterian, and 18 Independent. The number of scholars was 29,687. Of ordinary schools there were 642, with 37,289 scholars.

North-West Passage.

The title of Duke of this county belongs to the family of Percy, which passed into the female line in the last century. The Earl of Carlisle derives his second title from the town of Morpeth. This county is included in the northern circuit. The assizes are held at Newcastle thrice a year, and the quarter-sessions successively at Newcastle, Morpeth, Hexham, and Alnwick. For the purposes of election two divisions are formed, each returning two members. The elections for the northern division are held at Alnwick, and the polling-places are, besides that town, Berwick, Elsdon, Morpeth, and Wooler; for the southern they are held at Hexham, and the other polling-places are Bellingham, Haltwhistle, Newcastle, and Stamfordham. Besides Newcastle and Berwick, each of which returns two members, Morpeth, which, previous to the Reform Bill, had two members, still retains one. By the same act one member was given to the borough of Tynemouth, which includes the town of North Shields, with a considerable rural district around it. The towns containing more than 2000 inhabitants, with their population in 1851, were the following:—

Newcastle	87,784	Alnwick	6231
Tynemouth	29,170	Hexham	4601
Berwick	15,094	Blyth	2060
Morpeth	10,012		

The noblemen's and gentlemen's seats are generally handsome edifices, but those especially worthy of mention are Alnwick Castle, the residence of the Duke of Northumberland, and Chillingham Castle, that of the Earl of Tankerville. Alnwick Castle is at present undergoing most extensive improvements at an enormous cost, which, when completed (in about 1860), will render it the most complete and magnificent baronial residence in England. Lord Ravensworth resides at Eslington Park during a portion of the year, but his principal seat is Ravensworth Castle, in the county of Durham. Howick Hall is a handsome building by Paine, under whose superintendence many of the mansions of the Northumbrian gentry were rebuilt about the middle of the last century. Bamburgh Castle, an ancient royal fortress, and the seat of the Northumbrian kings during the Heptarchy, came into the possession of Nathaniel, Lord Crewe, Bishop of Durham, who left extensive estates to trustees for charitable purposes. The castle has been restored and fitted up for the occasional residence of the trustees. Ford Castle was rebuilt about a century ago by the late Lord Delaval. It is now the property of the Marquis of Waterford, whose agent occupies the castle. The modern additions are in bad taste, but there are interesting remains of the ancient fabric, long the residence of the noted border family of Heron. The remains of castles now in ruins are Norham, Etal, Dunstanburgh, Warkworth, Prudhoe, Langley, and Thirlwall, with many others of minor importance. Of Wark and Mitford little remains but the foundations. Bothal has been fitted up as a residence for the agent of the Duke of Portland; and Morpeth for the agent of Lord Carlisle. (J. H.)

NORTH-WEST PASSAGE. See POLAR REGIONS.

NORTH-WESTERN PROVINCES.

Divisions and Districts.

THE NORTH-WESTERN PROVINCES OF BENGAL form one of the great political divisions of Hindustan, comprehending a vast tract of territory, and constituting a sort of vice-presidency under the chief government of India. The administration is conducted by an officer, bearing the title of lieutenant-governor, who is appointed by the governor-general in council. These provinces, intersected by the Jumna and the Ganges, lie between Lat. 23. 51 and 30. 26., Long. 75. 20. and 84. 40.; and are bounded on the N. by the Deyra Dhoon, Kumaon and Nepaul; on the E. by Nepaul, Oude, and the lower provinces of Bengal; on the S. by the lower provinces of Bengal and the native state of Rewah; and on the S.W. by Bundelcund, Scindia's territory, and Rajpootana. The whole territory, comprehending an area of 76,190 square miles, with a population, according to the census of 1852-53, of 30,473,927, is distributed into six divisions and thirty-three districts. In the following list the names in capitals are those of the provinces, the others of districts. But there are districts also bearing the same name as the provinces, except in Rohilcund. The order is from north to south.

1. MEERUT,	ROHILCUND,	1. ALLAHABAD,
2. Dehra Dhoon,	1. Bijnour,	2. Cawnpore,
3. Saharunpore,	2. Moradabad,	3. Futtehpore,
4. Mozuffurnuggar,	3. Budaon,	4. Humeerpore and Calpee,
5. Boolundshuhur,	4. Bareilly and Pillibheet,	5. Banda.
6. Allygurh.	5. Shahjehanpore.	
1. DELHI,		1. BENARES,
2. Bhuttiana,	1. AGRA,	2. Goruckpore,
3. Paneeput,	2. Muttra,	3. Azimghur,
4. Hurreeanah,	3. Furruckabad,	4. Jaunpore,
5. Rohtuk,	4. Mynpoorie,	5. Mirzapore,
6. Goorgaon.	5. Etawah.	6. Ghazeepore.

Under the general arrangement for the government of India (3d and 4th William IV., cap. 85), the then existing Presidency of Bengal was to be divided into two Presidencies,—one retaining the previous name, the other to be called the Presidency of Agra. This plan, however, was not carried out; and by an act subsequently passed (5th and 6th William IV., cap. 52), power was given to the East India Company to suspend its operation, and to the governor-general in council to appoint, during such suspension, a lieutenant-governor of the north-west provinces, exercising his powers within an extent of territory to be defined by the authority from whom he received his appointment, and with such limitations as the same authority might deem fit. Agra is the seat of the government thus established, from which circumstance the officer administering it is usually styled the Lieutenant-Governor of Agra. In addition to the limits above defined, the jurisdiction of this functionary extends over some considerable tracts denominated the non-regulation districts, comprising the Saugor and Nerbudda territories, the Butty territory, the districts of Gurwhal, Ajmere, &c. By the Act of the Governor-General in council, dated the 9th of January 1858, Delhi and Meerut, or some portions thereof, were placed under the Chief Commissioner of the Punjab.

Mutiny of 1857.

Causes of the sepoy mutiny of 1857.

As the great mutiny of the Bengal army in 1857, though extending in some instances to Lower Bengal, and other parts of India, was chiefly confined to the north-west provinces, the insertion of the present article seems to afford a fitting opportunity for giving a summary of the principal occurrences connected with that extraordinary event. At the commencement of the year just mentioned a degree of uneasiness was first observed in a brigade of native infantry stationed at Barrackpore, and the natives attached to the depot of musketry at Dum Dum, in the vicinity of Calcutta. A rumour had been insidiously spread that the sepoys were to be forced to embrace the Christian faith, and that as a prelude to the change, and with the view of entrapping the troops into a loss of caste, the government had given orders that the grease employed in the arsenal, in the manufacture of cartridges for the new Enfield rifle, should be composed of the fat of pigs and cows. In using this description of cartridge one end is bitten off previous to loading; and as the Mohammedan regards the hog as impure, while the Hindoo looks upon the cow as a sacred animal, it would be alike repugnant to the religious prejudices of both creeds to apply the new ammunition to the mouth. The rumour appears to have been first put in circulation at Dum Dum. At this place a low-caste Hindu meeting a Brahmin sepoy, attached to the depot of musketry, solicited a draught of water from his lotah or drinking-cup. The Brahmin refused, observing, "I have scoured my lotah, and you will defile it by your touch." "Caste!" was the taunting rejoinder, "you think much of your caste, but wait a little; you are all going to eat bullock's fat, and then what will become of your caste?" The news spread rapidly through the cantonment, and soon extended to Barrackpore. At both stations it produced a high degree of excitement. An investigation into the matter was forthwith instituted under the orders of the government. In the course of the inquiry it was ascertained that hog's lard did not in any way enter into the composition of the grease. At the same time, it could not be satisfactorily shown from what description of animal the tallow was obtained; and, as under this doubt it would have been impossible to convince the sepoys that the ingredients were of an inoffensive character, the government at once determined to remove all cause of objection by ordering the cartridges to be issued altogether free from grease. A notification was accordingly promulgated abolishing the use of fat in the composition; but as the application of some greasy substance was absolutely necessary for the purpose of lubricating the bore of the rifle, the men were directed to apply with their own hands whatever mixture they might prefer. The alleged grievance being thus promptly redressed, and a full[1] explanation of the matter having been made by the commanding officers, both at Dum Dum and

[1] The address to the troops by Major-General Hearsey, commanding at Barrackpore, is remarkable for its manly and straightforward character. In a letter to the government, dated the 11th February 1857, he observes,—"I must mention that I had the whole brigade paraded on Monday afternoon, the 9th, and myself energetically and explicitly explained, in a loud voice, to the whole of the men the folly of the idea that possessed them, that the government or that their officers wished to interfere with their caste or religious prejudices, and impressed on them the absurdity of their for one moment believing that they were to be forced to become Christians. I told them the English were Christians of the Book, *i.e.*, Protestants; that we admitted no proselytes but those who, being adults, could read and fully understand the precepts laid down therein; that if they came and threw themselves down at our feet, imploring to be made "Book" Christians, it could not be done; they could not be baptized until they had been examined in the tracts of the Book, and proved themselves fully conversant in them, and then they must of their own goodwill and accord desire to become Christians of the Book ere they could be made so. I asked them if they perfectly understood what I said, especially the 2d Grenadiers; they nodded assent: I then dismissed the brigade. I have since heard from officers commanding regiments, that their native officers and men appeared quite ("koosh") pleased, and seemed to be relieved from a heaviness of mind that had possessed them."

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at Barrackpore, the sepoys appeared perfectly satisfied that no intention existed of interfering with their religious prejudices. Shortly afterwards, however, a similar spirit of discontent developed itself at Berhampore, a military cantonment near Moorshedabad. An escort party of the 34th native infantry from Barrackpore had made known to the sepoys of the 19th regiment native infantry stationed at Berhampore the objections which had been urged against the new cartridges by their comrades at Barrackpore and Dum Dum; and though they had been apprised of the remedial measures which had been adopted, a conviction seemed nevertheless to be gaining ground that the government were steadily bent upon making the sepoys lose caste by forcing them to handle impure things. The men were consequently ripe for outbreak. On the 26th of February the regiment was ordered to parade for exercise with blank ammunition. When the cartridges[1] were about to be issued, the men, one and all, refused to receive them, upon the ground that the paper of which they were made was glossy, and when burned gave out a smell of animal fat. The plea was wholly without foundation. Upon being analyzed the paper proved to be free from all greasy or oily matter. Under these circumstances, it became obvious that any farther continuance in a conciliatory course would be most impolitic. From the moment that the main facts of the outbreak were established, every member of the government felt satisfied that no penalty short of the disbandment of the regiment would meet the case. A severe example, it was hoped, would have the effect of convincing the native troops that they would only bring ruin upon themselves by failing in their duty to the state, and in obedience to their officers. In this expectation the men were marched down to Barrackpore, where, on the 31st of March, the regiment was formally disbanded. The example was at first believed to have produced the desired effect; and it was asserted that a better spirit had begun to prevail among the native troops. But almost immediately after, a European detachment was hurried down from Dum Dum to Calcutta, where an alarm had broken out, upon its becoming known that two sepoys of the 2d regiment of native infantry, while on duty at the fort, had been detected in an attempt to bring over the guard of the Calcutta Mint. In the following month a sepoy, and one of the native officers of the 34th native infantry stationed at Barrackpore, were found guilty of mutiny, and sentenced to be hung; and on the 6th of May the general insubordination of the sepoys rendered it incumbent upon the government to disband and dismiss from the service seven companies of the same regiment quartered at that place. At this juncture, moreover, information reached Calcutta of the mutinous conduct of the 7th regiment of the Oude irregular infantry at Lucknow.

General outbreak.

These partial mutinies at Barrackpore, Fort William, Berhampore, and Lucknow, indicating a wide-spread spirit of disaffection, were but the forerunners of the general revolt of almost the entire native army of Bengal. About the middle of May, the startling intelligence reached Calcutta that the flame of insurrection had burst forth at Meerut and Delhi; that six regiments quartered in those cities, viz., the 11th and 20th native infantry, and the 3d light cavalry, at Meerut, and the 38th, 54th, and 74th native infantry at Delhi, had risen in open mutiny, and that the insurgents had seized and retained possession of the city of Delhi. The announcement excited an all-absorbing interest throughout all classes of the community. Every one felt that a crisis was at hand, demanding from those who were called upon to encounter it the exercise of a vigorous judgment, combined with the most resolute courage and the greatest promptitude of decision. The government were not slow in proving themselves equal to the occasion. A proclamation forthwith appeared, disavowing all intention on the part of the state to interfere with the caste or religion of its subjects;[2] and this preliminary step being taken, Lord Canning proceeded to meet the emergency with all the energy and determination which we are wont to admire in the earlier history of our Indian conquests. The one great object was to procure European troops. For this purpose prompt measures were adopted for intercepting the military force then on its passage from England to China; earnest requisitions for reinforcements were simultaneously dispatched to the Mauritius, Ceylon, the Cape of Good Hope, and Great Britain; and these were followed by the most vigorous preparations for concentrating in the disturbed districts the scattered military resources of the empire. In the following narrative, an attempt is made to connect the leading events which mark the progress of this momentous outbreak.

Mutiny of 1857.

Meerut.

Early in May 1857, the 3d regiment of Bengal light cavalry, stationed at Meerut, refused to continue the use of the old cartridges; none of the new ammunition, as already observed, having been issued to any native regiment. For this act of mutiny all the men of the regiment armed with carbines were tried by court-martial, and eighty-five of their number sentenced to imprisonment for ten years with hard labour. The sentence was read at a general parade of the troops on the 9th of May, and the prisoners, after being ironed on parade, were marched off to the jail. Two other native regiments, the 11th and the 20th infantry, were also quartered at Meerut; and on the following day, the 10th of May, the men of these corps broke out in open mutiny, and joined the disaffected light cavalry. Col. Finnis, of the 11th regiment, attempting to expostulate with the men, was shot by the insurgents of the 20th regiment. Several other British officers were then singled out as victims, and all Europeans—men, women, or children—upon whom the miscreants could lay hands, were ruthlessly murdered. The loss of life extended to about forty individuals. In the course of the night the mutineers,

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[1] These were the old cartridges which the regiment were in the habit of using. It is, indeed, worthy of remark, that the new cartridges had been issued only to the musketry depots at Dum Dum, Umballah, &c., and not to any native regiment. They were adapted exclusively to the new Enfield rifle; and as the native regiments were armed hitherto with the common musket, it would have been useless to have issued them.

[2] The proclamation ran as follows:—"The Governor-General of India in council has warned the army of Bengal, that the tales by which the men of certain regiments have been led to suspect that offence to their religion, or injury to their caste, is meditated by the Government of India, are malicious falsehoods. The Governor-General in council has learnt that this suspicion continues to be propagated by designing and evil-minded men, not only in the army, but amongst other classes of the people. He knows that endeavours are made to persuade Hindus and Mussulmans, soldiers and civil subjects, that their religion is threatened secretly, as well as openly, by the acts of the Government, and that the Government is seeking in various ways to entrap them into a loss of caste for purposes of its own. Some have been already deceived and led astray by these tales. Once more, then, the Governor-General in council warns all classes against the deceptions that are practised on them. The Government of India has invariably treated the religious feelings of all its subjects with careful respect. The Governor-General in council has declared that it will never cease to do so. He now repeats that declaration, and he emphatically proclaims that the Government of India entertains no desire to interfere with their religion or caste, and that nothing has been or will be done by the government to affect the free exercise of the observances of religion or caste by every class of the people. The Government of India has never deceived its subjects. Therefore the Governor-General in council now calls upon them to refuse their belief to seditious lies. This notice is addressed to those who hitherto, by habitual loyalty and orderly conduct, have shown their attachment to the government, and a well-founded faith in its protection and justice. The Governor-General in council enjoins all such persons to pause before they listen to false guides and traitors, who would lead them into danger and disgrace."

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Delhi.

having previously rescued the eighty-five prisoners of the light cavalry who had been sentenced to hard labour, and having fired the cantonments, retired in the direction of Delhi. This place the mutineers reached on the 11th. Crossing the Jumna by the bridge of boats, they made direct for the palace of the king, where, being promptly admitted, they sallied forth into the town. Here they were met by the Delhi troops, consisting of the 38th, the 54th, and the 74th native infantry. Both parties evidently understood each other. The three regiments at once fraternized with the rebels. This being done, they turned upon their officers, many of whom they shot or cut down; then continuing the career of atrocity commenced at Meerut, they proceeded to murder all Europeans wherever they could be found. The number who thus perished is said to have been very great. The next step of the mutineers was to take possession of the fort and city, and to secure the bridge of boats over the river. Lieutenant Willoughby, the commissary of ordnance, held charge of the magazine, and finding that the rebels were escalading the walls by means of ladders, which had been supplied from the palace, gallantly blew up the building. Unhappily, this heroic soldier received severe injuries, and did not long survive the daring act. All the Europeans within the palace were slaughtered with the concurrence, if not by order of the king, and the restoration of the house of Timour was proclaimed. Delhi, thus captured, remained in the occupation of the mutineers; and no inconsiderable portion of the Bengal army was now arrayed in armed resistance against the lawful rulers of the country. On the part of the British, it was felt that the prompt recapture of the city was of the first importance, it being obvious that the preservation of order throughout the north-west provinces was mainly dependent upon the early and signal discomfiture of the rebels. Delay, however, was unavoidable. The commander-in-chief, General Anson, hastening down to Delhi from the hill station of Simlah, reached Kurnaul on the 25th of May, where he was attacked by cholera, and fell a victim to the disease on the 27th of May. Upon this the command of the army devolved upon Major-General Sir H. Barnard, who, having been joined by the troops of the Rajahs of Jheend and Pateeala, moved on towards Delhi, and reached Allipore, 10 miles from the city, on the 5th of June. Before, however, the new commander could reach the captured city, the insurgents sallied forth in great force, and attacked a portion of the troops from Meerut under Brigadier-General Wilson, at Ghazee-ood-deen Nuggur. The attack was made on the 30th of May, and repeated on the 31st; but the assailants were thoroughly beaten and dispersed, leaving behind them five guns, and large stores of ammunition. Our loss on the two occasions amounted to 23 killed and 31 wounded. On the 8th of June, General Barnard advanced from Allipore, and being joined by Brigadier Wilson, made a spirited attack upon the enemy's intrenched outposts at Badlee-ke-serai, captured the heights in front of Delhi, together with 26 guns, and drove the rebels, dispirited, within the walls of the city. The position thus secured by the British extended from the river on the left, along the ridge facing the north side of the city as far as the Subzee Mundee suburb on the right, where the hilly ridge terminates; the distance from the city walls averaging from 1200 to 1500 yards. On this occasion a most determined resistance was shown by the enemy, and the loss of the British was no less than 51 killed and 134 wounded or missing, with 63 horses. Next day, and again on the 10th and the 11th, the enemy attacked the British position, but were repulsed, and retreated within the city. On the 12th a very serious attack was made by the mutineers on the flagstaff picquet, nearly in the centre of the British position, and a few hours afterwards, at the Subzee Mundee, on the British extreme right. The 60th native infantry, which had been detached to Rohtuck, and had there mutinied and joined the insurgents at Delhi, suffered much in this encounter. An assault upon the city had been arranged for the 13th of June, but, owing to the mistake of a superior officer in delaying to withdraw the picquets—without which the columns of attack would have been too weak—was abandoned. On the 15th the rebels again made a sortie, attacked the Metcalfe picquet, and tried to turn the left flank of the British, but after a sharp action, were repulsed with great loss. On the 17th the enemy opened a very heavy cannonade to cover some batteries they were constructing. A single shot fired by them killed Ensign Wheatley of the 54th native infantry, and killed or wounded nine men. At 4 P.M. Majors Tombs and Reid led two columns to the attack of the works the rebels had just commenced, and destroyed them, losing only 18 killed and wounded. On this day the mutineers were reinforced by the Nusseerabad brigade, consisting of the 2d company 7th battalion artillery, No. 6 horse battery, the 15th and 30th native infantry, and a few troopers of the 1st Bombay lancers. On the 19th the enemy attacked the British position in great force, a very large body of them having got in the rear of it. The action lasted till late at night, and was renewed next morning. It ended in the retreat of the rebels, but the British loss was 10 officers, 89 men, and 60 horses killed, wounded, or missing. Lieutenant-Colonel Yule, of the 9th lancers, was among the killed. On the 21st the rebels were joined by the 6th light cavalry, the 3d, 36th, and 61st native infantry from Jullundur and Phillour. On the 23d of June, being the centenary of Plassey, the rebels made a determined sortie, which was not repulsed without severe loss to the British. A gun was disabled, and 4 officers and 156 men were killed or wounded. On the 27th, and again on the 30th, sorties were made, which the British repulsed, with the loss to themselves of 62 killed and wounded on the first occasion, and 46 on the second; but they were now joined by fresh troops, which, on the 3d of July, made up the besieging army to 6600 men of all arms. It was now again proposed to attempt to take the city by a *coup de main;* but the idea was again abandoned. On the 1st and 2d of July, the 8th irregular cavalry, the 18th, 28th, 29th, and 68th native infantry, No. 15 horse battery, and two 6-pounders, from Rohilcund, marched into the city across the bridge of boats. On the 3d the rebels moved a force of several thousand men against Allipore, which they plundered; but next day the plunder was retaken by Major Coke after a sharp skirmish. Further attacks were made by the rebels on the 4th and 9th of July, in the last of which the British loss amounted to 211 killed and wounded.

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General Barnard was attacked with cholera, and died on the morning of the 5th. The vacancy was supplied by General Reed; but before the close of the month this officer also was compelled, by severe illness, to hand over the chief command to General Wilson. On the 9th the enemy made a spirited sortie, and 100 of their horse charged right into camp, cutting down Lieutenant Hills and some camp followers. At the Subzee Mundee the fire was very hot. The total British loss was 9 officers and 214 men killed and wounded. In spite of past defeats the mutineers, on the 14th of July, made a bold attempt to capture the British batteries. The attempt proved abortive; but so fierce was the onset that the assailants inflicted a loss upon their opponents of 16 officers, including Brigadier Chamberlain, and 194 men killed and wounded. On the 18th the last serious engagement in the Subzee Mundee took place, when the total of British casualties was 11 officers and 80 men. The British works were henceforward so complete in this place that the enemy could effect nothing. Again, on the 23d, the rebels came out in considerable strength, and moved upon the British position at the Metcalfe battery. Here they were taken in flank by a force under Brigadier

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Showers, and put to precipitate flight. A lull of a few days succeeded; but on the 31st of July, the anniversary of the Mohammedan festival, styled "Buckree Eed," the enemy poured out in great force, and commenced a general attack upon the advanced posts of the British. The contest was continued without intermission, day and night, until the morning of the 2d of August. Never before had the rebels displayed so great an amount of determination. Although their courage invariably failed them when about to make the final rush, yet never before had they so closely approached the British breastworks. Throughout this prolonged encounter, the British, well under cover, inflicted terrible punishment upon the enemy, with slight loss to themselves; and when, about noon on the 2d, the rebels drew off the dead and wounded, who lay in heaps before the British works, of the British only 46 of all ranks were wounded. A few days later (12th of August), a battery which had been opened by the enemy outside the walls, bearing upon the point known as Metcalfe House, was captured by a force under Brigadier Showers, who was severely wounded. In this gallant affair the casualties among the British extended to 117 killed and wounded; many of the latter, however, were but slightly injured. It may be here stated that, inclusive of three or four minor contests which it has not been thought necessary to notice, the number of engagements fought in front of Delhi from the date of the insurrection to the commencement of August, amounted to no less than twenty-three. In these the aggregate loss of the British was 318 killed and 1062 wounded. Of the former, 22 were officers and 296 privates; and of the latter, 72 were officers, the remainder consisting of rank and file. With respect to the mutineers, though their losses from their multiplied defeats must have been enormous, still their numerical strength was throughout far superior to the English; for, in addition to the reinforcements already mentioned, they had received a wing of the 12th native infantry, the 14th irregular cavalry, and half No. 18 light field battery from Jhansi, and the Neemuch brigade—viz., a troop of horse artillery, a wing of the 1st light cavalry, the 72d native infantry, the 7th Gwalior contingent, and the cavalry and infantry of the Kotah contingent, which arrived late in July, besides many smaller bodies.

After the fruitless attempt of the 1st of August, the enemy appear to have lost all hope of dislodging the British, and for upwards of three weeks remained comparatively inactive, under shelter of their fortifications. On the 8th of August Brigadier Nicholson arrived in the camp with a strong brigade from the Punjab, bringing up the strength of the English army to 8122 rank and file, besides 1535 sick, and 304 wounded. On the 13th a body of the enemy's cavalry left Delhi by the Nujufgurh road, with a view, it was thought, of interrupting the British communications with the Punjab. Several parties of them were cut up by Lieutenant Hodgson with his horse and the guide cavalry, and he returned to camp on the 22d. On the 24th a strong column of the rebels with 18 guns, proceeded in the Bahadurgurh direction, to intercept the field-train coming to the British camp from Ferozepore. General Wilson, penetrating the design, despatched a force in pursuit, under Brigadier Nicholson, who came up with the rebels on the 26th, posted at Nujufgurh. Here he attacked them with great success, captured all their guns, and drove them back broken and dispirited to Delhi. Their loss was estimated at between 300 and 400; that of the British was 95 killed and wounded. On the morning of the 27th a sortie was made from Delhi, under the impression that the British force was much weakened by the despatch of the force under Brigadier Nicholson, who had not yet returned; but the attack was easily repulsed.

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By the 6th of September, all the British reinforcements that could be looked for, together with the siege-train, had arrived. It was now determined to commence regular siege operations, and the effective force for that purpose amounted to 8748 men. There were besides in hospital 2977. The Europeans were—of artillery, 580; cavalry, 443; infantry, 2294. There were also the Cashmere contingent of 2200 men with 4 guns, and some hundred men under the Jheend Rajah.[1]

The north face, from which side the stronghold of the rebels was to be attacked, comprised the Moree, Cashmere, and Water bastions, with the curtain-walls connecting them. Four batteries armed with heavy guns having been established in commanding positions, and within a short distance of the walls, the bombardment commenced on the 11th of September. In planning the attack one great object kept in view was to divert attention from the real point of the intended assault, and in this the British commander completely succeeded, the enemy obviously concluding, from their preparations that the attack was to be made from a point more to the right. On the night of the 13th two breaches near the Cashmere and Water bastions being examined by the engineers, and pronounced practicable, orders for the assault were issued to take place at daybreak the following morning. The arrangements for the storming, which was to be made by four columns and a reserve, were as follows:—1st column, Brigadier-General Nicholson,—Her Majesty's 75th regiment, 1st Bengal fusiliers, and 2d Punjab infantry: to storm the breach near the Cashmere bastion, and escalade the face of the bastion. 2d column, Brigadier Jones, C.B,—Her Majesty's 8th regiment, the 2d European Bengal fusiliers, and 4th Sikh infantry: to storm the breach in the Water Bastion. 3d column, Colonel Campbell,—Her Majesty's 52d regiment, the Kumaon battalion, and 1st Punjab infantry: to assault by the Cashmere gate after it should be blown open. 4th column, Major Reid,—Detachment of European regiments, Sirmoor battalion, Guide infantry, and detachment of Dograhs: to attack the suburb Kissengunge, and enter the Lahore gate. 5th column, Brigadier Longfield,—Her Majesty's 60th Rifles, Kumaon battalion, and 4th Punjab infantry: the reserve.

At four o'clock A.M. the several columns were marched to their respective positions, the heads of Nos. 1, 2, and 3 being concealed until the moment for action should arrive. The signal for the assault was to be the advance of the Rifles to the front to cover the heads of the columns by skirmishing. Upon the word of command being given, the Rifles dashed to the front with a shout, skirmishing along and through the low jungle which extended to within 50 yards of the ditch. At the same moment Nos. 1 and 2 columns, the one headed by General Nicholson and the other by Brigadier Jones, and consisting respectively of 950 and 850 men, emerged from the Koodsee Bagh, their place of concealment, and steadily advanced towards the breaches. On attaining the open space they were met from the front and both flanks by a storm of bullets, and officers and men fell fast on the crest of the glacis. For ten minutes it was found impossible to get the ladders down into the ditch, but the resolution of the British soldier carried all before it. The scarp was ascended, and with a cheer and a rush both breaches were won, and the enemy fled in confusion. In the meantime the third column, consisting of 950 men under Colonel Campbell of Her Majesty's 52d light infantry, made direct for the Cashmere gate, preceded by the explosion party under Lieutenants Home and Salkeld of the en-

[1] The British troops actually engaged in the recapture of the city amounted to 2100 men.

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gineers. This little band, advancing in broad daylight to the gateway in the teeth of a sharp fire of musketry, coolly proceeded to adjust the powder bags. During the daring enterprise Lieutenant Salkeld received two gunshot wounds. His first shot was through the arm; notwithstanding this he went on to the gate, and while assisting in fastening the bags on the spikes, he was shot through the thigh, and fell. Sergeant Carmichael stepping forward to fire the train, was shot dead. Sergeant Burgess then made the attempt with better success, but paid for it with his life. Sergeant Smith, believing that Burgess had also failed, sprang forward, but seeing the train alight, threw himself into the ditch, and escaped the effects of the explosion. A tremendous crash announced that the gate was blown in, and the 3d column rushed to the assault, and entered the town at ten o'clock, just as the 1st and 2d columns had won the breaches. To four of the little band of heroes who accomplished the destruction of the gate the Victoria cross was afterwards awarded, viz., to Lieutenants Home and Salkeld, of whom the former was killed on the 1st of October by the premature explosion of a mine in destroying the fort of Malagurh, and the latter died of his wounds received at Delhi. The other two on whom the cross was bestowed were Sergeant Smith and a soldier of Her Majesty's 52d, who bound up Lieutenant Salkeld's wounds. General Nicholson having formed the troops within the walls, directed his advance along the ramparts, occupying the defences as far as the Moree bastion. Here, while endeavouring to penetrate still further in the direction of the Lahore gate, this most able, zealous, and gallant soldier, whose exploits during the Afghan and Sikh wars, and recent victory at Nujufgurh, had covered him with glory, received a wound at the head of the advancing column, which, on the 23d of September, terminated in his death. Unhappily the 4th column, which had been destined to carry the suburb of Kishengunge and enter the Lahore gate, failed in the enterprise. The principal loss sustained by the assailants was due to the obstinate resistance they met with in clearing the way from the Moree bastion to the Caubul gate, in a vain attempt to take the Burn bastion, and in the repulse at Kishengunge. On the day of the assault alone the loss amounted to 1104 men killed and wounded, and 66 officers, exclusive of the losses of the Cashmere contingent, or Dograhs, who were completely routed by the rebels, and fell back to camp, leaving four guns in the hands of the enemy. The loss of the enemy is given at 1500 men. A permanent lodgement having been now effected, preparations were made on the 15th for shelling the rebels out of the palace, the fort of Selimgurh, and the other strong positions of the city. At dawn on the 16th the magazine was stormed. In it were captured 125 pieces of cannon. The palace now lying well exposed from this point, the guns opened upon it from the inclosure. The Kishengunge battery, which had repulsed the 4th column, was now evacuated by the enemy, and the guns there taken swelled the number of captured pieces to 200. On the 16th a chain of posts had been established from the Lahore gate to the magazine, and on the 19th the line was advanced to the Chandnee Chouk, the principal street of the city. By the last mentioned day the resistance of the mutineers had become less decided; and in the evening of that day the Burn bastion was captured by surprise, and early next morning the Lahore gate and Garstin bastion were taken and held. At length the enemy maintained only a desultory warfare from the tops of the houses; and on the 20th of September, after an arduous struggle, continued during seven days, the labour of the gallant troops were crowned with complete success, and the city of Delhi was once more in the exclusive possession of the British. Large bodies of the mutineers effected a timely escape. Among the fugitives were the king of Delhi and his two sons and grandson. The royal party fled in disguise along the road south of the city, the king being accompanied by his favourite wife the Begum Zeenut Mahal, "the Ornament of the Palace." On the 21st of September the king surrendered to Captain Hodson, who succeeded also in capturing his two sons, Mirza Mogul and Mirza Khizr Sultan, together with his grandson, Mirza Abu Bukr, at the tomb of Humayoon, about 5 miles from Delhi. The life of the king, now nearly ninety years of age, has been spared, and he may be safely allowed to pass the remainder of his days in peaceful exile. Not so the younger princes of the family. His sons and grandson, who were known to have taken an active part in the rebellion, on being taxed with their guilt, craved for mercy. But stern justice alone was to be dealt to them, and they were at once sentenced to be shot. Their execution took place at the Delhi gate on the 22d September. After the recapture of the city, General Wilson, then suffering from severe illness, resigned the command of the field force to General Penny, who, on the morning of the 24th of September, despatched Lieutenant Colonel Greathed of Her Majesty's 8th regiment, with a strong moveable column to clear the Doab, and endeavour to open communications with General Havelock at Cawnpore.

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Cawnpore.

Cawnpore, one of the great military stations of the East India Company, is situated on the right or western bank of the Ganges, immediately opposite to the territory of Oude. In the spring of 1857, the military quartered here consisted of three regiments of native infantry and one of native cavalry, together with a detachment of Her Majesty's 84th regiment. For some weeks previous to the outbreak, the native troops were known to have largely participated in the general excitement caused by the insidious rumours regarding the defiled cartridges. Symptoms of insubordination had been manifested from time to time in the ranks; and at length, on the night of the 4th of June, the 1st regiment of infantry and the 2d light cavalry rose in open mutiny. At their head appeared a Hindoo rajah known as Nana Sahib. This monster in human form was the adopted son of the late ex-Peishwa, Bajee Rao of Poona, and as such he had laid claim to the reversion of the pension which the latter enjoyed from the British. His pretensions, however, were overruled by the government, and his subsequent atrocities would thence appear to have been prompted by personal resentment. Nana had been on terms of intimacy with most of the British officers at Cawnpore. He spoke English, possessed a smattering of European literature, and was regarded by those who knew him as shrewd and intelligent. Before the mutiny broke out, and while the authorities were temporizing in the hope that the recapture of Delhi would restore peace and order, Nana proposed to strengthen the garrison of Cawnpore by the addition of his own troops. His offer was accepted, and about 300 or 400 men were brought down from his castle at Bithoor, and located near the magazine. At the same time he invited the officers to send their wives and children to Bithoor as a place of safety. On the 4th of June, when the mutiny broke out, Nana placed himself at the head of the rebels, saying "I came in appearance to help the British, but am at heart their mortal enemy." On the following day the 53d and 56th regiments renounced their allegiance, and joined the mutineers. Nana was not slow in proving himself the fitting commander of the rebel force. An alarm having broken out at Futtygurh, a military station situate about 70 miles above Cawnpore, a party of 132 Europeans, consisting of men, women, and children, hurriedly quitted that place in boats, and were proceeding down the river towards Allahabad. Upon arriving off Bithoor, Nana opened fire upon them. An order was then given to board the boats, which being done, the fugitives were seized and dragged to the parade-ground at Cawnpore, where the whole party were barbarously murdered. In the meantime the British force at Cawnpore

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had taken refuge, together with the women and children, within an intrenched camp under the command of Sir Hugh Wheeler. Here, though besieged by a force 5000 strong, the garrison succeeded in repelling every attack, and, moreover, frequently sallied out from the intrenchments to disperse the rebels. In one of these sorties their gallant leader was severely wounded, and his little band, dispirited by the disaster, worn out by constant watching, enfeebled from want of food, and encumbered moreover with a number of women and children, were induced to surrender, upon receiving the solemn promise of Nana that they should be allowed to withdraw with the whole of the European population to Allahabad. The capitulation was made out on the 1st of July. Upon giving up the treasure, with the guns and ammunition, the garrison with their followers were permitted to embark. But the moment had now arrived for carrying out Nana's meditated treachery. He had never intended that his victims should be allowed to escape. No sooner had the boats loosened from the shore than a fire of artillery was treacherously opened upon them. The boats, with one exception, were then brought back, and the surviving occupants once more landed, when Nana, in spite of his solemn pledge, issued his mandate for the indiscriminate massacre of the male portion of the prisoners. The boat containing General Wheeler does not appear to have been captured until nearly 22 miles below Cawnpore, when it was stopped, and all on board carried prisoners to Nana. Amongst them, besides the veteran commander, who was severely wounded, were Dr Harris and Captain Mackenzie. Their arms had been tied, and thus bound they were led off to execution. All met death bravely. Dr Harris fell saying that his countrymen would revenge his death. Lieutenants Henry Delafosse and Mowbray Thomson, both of the 53d native infantry, had escaped from the advanced boat by swimming. The women and children, in receiving a short respite, were but spared for a worse fate than instant death. For some days they were kept in the most agonizing suspense, and on the eve of the battle of Cawnpore all were barbarously murdered. The number of Europeans thus slaughtered between the 1st and the 15th July amounted in the aggregate to 868, and consisted of 88 officers, 190 rank and file of Her Majesty's 84th foot, 70 ladies, 120 women and children of Her Majesty's 32d foot, and 400 of the European population of the town, including civilians, merchants, shopkeepers, and others. If to these be added the number of fugitives who were intercepted in coming down the river from Futtyghur, the total number butchered by Nana amounts to no less than 1000 Europeans.

The relief of Cawnpore had been intrusted to Brigadier-General Havelock. This officer reached Allahabad on the 30th of June. At this time the relieving force under his command was composed of two European regiments recently withdrawn from Persia—viz., the 64th and the 78th, mustering together 1100 or 1200 bayonets. Moving on from Allahabad on the 4th of July, the general was joined by a small detachment under Major Renaud. With the combined force, which, inclusive of 561 native soldiers, counted in all but 1964 men, the general, on the 12th of July, encountered the rebels, amounting to 3500, with 12 guns, at Futtehpore, situated midway between Cawnpore and Allahabad, and put them to complete route, capturing all their guns. The loss of the British was, perhaps, the lightest that ever attended such signal success. It amounted to no more than 6 sepoys killed, and 8 wounded and missing. General Havelock pursued the enemy in the direction of Cawnpore. On the 15th he again attacked the rebels in their entrenched position, close to the village of Osung, capturing four more of their guns; and on the 16th he signally defeated Nana Sahib in front of Cawnpore. At this place the enemy were posted behind a succession of villages, where a determined stand was to be made. The fight was most stubborn, and every inch of ground was resolutely disputed during the space of nearly three hours. At length the fate of the day was decided by a flank movement of the 78th Highlanders turning Nana Sahib's left. "I never," says an eye-witness, "saw anything so fine." The men of the 78th went on, with sloped arms, like a wall. Till within 100 yards not a shot was fired. At the word 'charge,' they broke just like an eager pack of hounds, and the village was taken in an instant." Cawnpore now lay open to the British. The rebel chief retired in the direction of Bithoor, blowing up the magazine previous to his retreat. In this engagement the loss of the British was not inconsiderable, amounting to 70 killed and wounded out of a force falling short of 2000 men. This force, however, it must be borne in mind, had been opposed to 6000 mutinous sepoys, armed and disciplined after the English fashion. Upon entering Cawnpore on the following morning, the extent of the frightful catastrophe which had befallen the British garrison and the European residents first became fully known. A wholesale massacre had been perpetrated by Nana Sahib. The site was a paved courtyard. One writer describing the scene, observes:—"The blood was two inches deep upon the pavement; and from the report we got from the residents, it appears that after we had beaten the enemy on the previous evening, the sepoys entered the place where the unhappy victims were confined, killed all the ladies, threw their naked bodies into a well, and hurled down the children alive upon their butchered mothers. I saw it, and it was an awful sight." Long tresses of hair, torn bibles and prayer-books, work-boxes and unfinished work, scattered about the red floor, told too well the harrowing tale. Two or three only of the captives, who had been concealed by their native servants, contrived to escape. The daughter of Sir Hugh Wheeler perished among the victims. This heroic lady, who appears to have inherited the indomitable spirit of her father, is stated to have shot five of the fiends with a revolver before they could get sufficiently near to her to cut her down. Another lady, previous to her death, is declared to have avenged herself by destroying the ruffian who had carried her off, and who probably destined her for outrage. Upon reaching Bithoor in pursuit of the flying enemy, it was found that Nana had just evacuated the village, and the British commander was obliged to content himself with burning the palace of the rebel and bringing away the guns. General Havelock then crossed the Ganges into Oude, on his march to Lucknow, leaving General Neill in charge of Cawnpore. On the 28th July, he twice attacked the rebels, and defeated them in both engagements. Arriving at Oonao on the 29th, he found the place defended by 10,000 of the insurgent troops, including a portion of Nana Sahib's force. The village had been strongly fortified, and every house was loopholed. But the assault of the British was irresistible, and the enemy retreated, leaving behind them their guns. After a halt of four hours, the indefatigable and victorious commander pushed on for Futtehpore Chowrasee, distant about 30 miles from Lucknow. Here a desperate engagement ensued, which resulted in the capture of the town—the rebels withdrawing in the direction of Lucknow. On this occasion the British sustained a loss of 88 killed and wounded. After advancing still nearer to Lucknow, and fighting another battle, in which the British, though as usual victorious, incurred a loss of 85 killed and wounded, General Havelock had the mortification to find that farther progress was for the present impracticable. A body of the rebels, 25,000 strong, were posted in an intrenched position in his front; cholera was making its appearance in his small force, which had been already materially reduced by incessant combats and successive victories. The strength of the little band had indeed been overtaxed.

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Mutiny of 1857. It had gained more victories than had ever before been won in so short a time; but its numbers were now reduced below 900 men. In these circumstances, General Havelock, convinced of the impossibility of penetrating the thick masses of the insurgents, deemed it incumbent upon him to pause on his triumphant career, and to fall back upon Cawnpore. A retreat was accordingly commenced. The rebels, taking heart, closely followed in the rear, and advanced as far as Nawabgunge. Here the British commander, nowise daunted by the enemy's superiority of numbers, once more halted to give them battle. Again he was victorious; and, having added two more of the enemy's guns to his previous trophies, he leisurely crossed the Ganges, and on the 13th August rejoined General Neill at Cawnpore. Such a series of gallant exploits forms a brilliant episode in Indian history. The battles of Cawnpore and Oonao lose nothing of their brilliancy, even when compared with the victories of Clive and Wellesley. Having rested for a few days at Cawnpore, General Havelock marched a second time to Bithoor, where it was understood that the rebels, about 4000 strong, were posted with two guns. Here, on the 16th of August, with a force mustering 1300 men and 14 guns, he again encountered them; and, after an obstinate engagement, in which the enemy lost 250 killed and wounded, drove them from their position and captured their guns. The British loss was 14 killed and 30 wounded. General Havelock then determined to return to Cawnpore, there to await the arrival of reinforcements before advancing again upon Lucknow.

Lucknow. At Lucknow, the capital of Oude, as early as the 3d of May, the men of the 7th regiment of the Oude irregular infantry had mutinied. The city was held by Sir Henry Lawrence, one of the ablest and bravest officers of the Indian army. No time was lost in disarming the regiment. A strict investigation was then instituted, at the close of which it was deemed sufficient to dismiss the greater number of the native officers of the regiment, together with a few of the sepoys, and to overlook the conduct of the remainder. These conciliatory measures failed to produce a better feeling in the other regiments stationed at Lucknow. On the 30th of May an outbreak occurred, when about one-half of the men of the 48th and 71st native infantry, and some few of the 13th native infantry, with two troops of the 7th light cavalry, rose in insurrection. A sharp encounter followed, in which the mutineers sustained considerable loss, but the greater portion contrived to elude pursuit in the direction of Seetapore. The example thus set at Lucknow was promptly followed at every military station throughout the province. The troops at Seetapore mutinied on the 4th of June; those at Fyzabad and Secrora on the 8th; at Sultanpore and Pertaubghur on the 8th; at Pershadeepore on the 10th; and at Burraich and Gonda at dates not given. The regiments at these several stations consisted of two field batteries, two regiments of cavalry, and ten regiments of infantry. From Sultanpore, the 15th Oude irregular cavalry and the 8th irregular infantry, started at once for Delhi. It is worthy of remark, that at Fyzabad the mutiny was marked rather by the generous spirit of Europe, than by the barbarous customs of the East. Here the men after mutinying, actually saluted their officers, and placed the ladies under protection. All the outposts of Oude being thus lost, the mutineers gradually closed in upon Lucknow. The position of Lawrence was now becoming critical. His European force, the only one to be depended upon, was fearfully small. It consisted of 510 men of Her Majesty's 32d foot; and within the intrenchments there were no less than 350 women and children. Three positions only were held by the British,—the Residency, the Muchee Bhawan, and the cantonments. These were greatly strengthened, and the remaining military posts within the city were all abandoned. On the 30th of June, Sir H. Lawrence having learned, by a reconnoisance made on the previous day, that the rebel army were assembling at Chinhutt, about 10 miles from Lucknow, marched thither with 300 of Her Majesty's 32d, 150 of the 13th native infantry, 100 of the 48th and 71st, 125 Sikh horse, 30 mounted Europeans, 300 police, and 11 guns, of which 6 were manned by natives. On reaching the village of Chinhutt, he found the enemy to the number of 15,000 men, with 36 guns prepared to receive him. At the first shot the police went over in a body, and the native gunners, cutting the traces, galloped over to the enemy, or back to Lucknow. The rest of the force displayed prodigies of valour, natives vying with Europeans in daring acts; but overpowered by numbers, the whole body were compelled to retreat to the Residency at Lucknow, leaving 118 European officers and men killed, and 182 natives killed and missing, besides 54 Europeans and 11 natives wounded. The death of Colonel Case, commanding the 32d regiment, who fell at the head of his men, deserves to be recorded. Captain Bassano seeing him fall, went up to assist him. "Leave me to die here," were the words of the wounded hero; "your place is at the head of your company. I have no need of assistance." From the moment the force reentered the Residency, the siege of that place commenced. On the 2d of July Sir H. Lawrence was wounded by a fragment of a shell; and after suffering amputation of the leg, died on the morning of the 4th, having nominated Major Banks to succeed him as chief commissioner and commandant. On the 20th of July the enemy in vast numbers attempted to storm, but were repulsed with the loss of 1000 men. Next day Major Banks was killed, and was succeeded by Brigadier Inglis, who continued the gallant defence, and repulsed several attempts to storm, of which one on the 10th of August, and another on the 5th of September, were the most spirited. On the 25th of September, Generals Outram and Havelock, with a force originally consisting of 2500 men, cut their way to the Residency, and it becomes requisite, therefore, to return to the operations under Havelock at Cawnpore.

After the second battle of Bithoor, fought on the 16th of August, General Havelock, as above noticed, retraced his steps to Cawnpore, where he expected to be reinforced by fresh succours from Calcutta. Here, on the 14th September he was joined by a force under General Outram, who, though the superior officer, determined with chivalrous generosity to waive his rank on the occasion, and to leave to General Havelock the glory of relieving Lucknow, and rescuing its gallant and enduring garrison. In accordance with this determination, Sir James merely accompanied the force to Lucknow, in his civil capacity, as chief commissioner of Oude, at the same time tendering his military services to the general as a volunteer. On the 19th, General Havelock having formed his little army into two brigades,—of which the first consisted of Her Majesty's 5th fusiliers, the 64th and 84th regiments, the 1st Madras fusiliers, Captain Maude's troop of horse artillery, and 150 European volunteer cavalry; and the second of Her Majesty's 78th Highlanders, the 90th light infantry, Captain Olphert's horse battery, and some irregular horse,—crossed the Ganges into Oude; and on the 21st attacked the rebels at Mungarwar, and drove them from their position, capturing four guns, two of which, together with the colours of the 1st Bengal native infantry, were taken by the volunteer cavalry in a charge headed by Sir James Outram. The loss of the British was trifling.

On the 21st of September the indefatigable general accomplished a march of 14 miles, and one of 20 miles on the 22d, at the termination of which the firing at Lucknow was distinctly heard. A royal salute was then ordered by General Havelock to be fired to announce his approach to the garrison. On the 25th the British force, skirting the city,

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forced its way to the Residency against enormous numbers of the enemy, and with the loss of 550 officers and men; Brigadier Neill and Colonel Bazeley being among the killed, and Sir J. Outram being wounded.

It was now found that although, by a display of courage which has never been surpassed, the relieving army had made its way to the Residency, it was altogether too weak to remove the besieged, of whom the greater part were sick and wounded, and women and children. On the contrary, Generals Outram and Havelock were now themselves besieged, and their communications even with Alumbagh, where they had left their baggage with a guard of 300 men, were entirely cut off. At a short distance from the Residency, in the palace called the Kaiserbagh, were eight European prisoners, Sir M. Jackson, C.S., and his sister; Captain P. Orr, his wife, and child; Lieutenant Burnes, Sergeant Norton, and Miss Christian; but nothing could be done to relieve them, and all the males were subsequently blown from guns by the rebels. Every day desperate conflicts took place in the inclosure to clear the buildings surrounding the Residency. Sir J. Outram had now taken command; and on the 26th of September ordered a sortie, under Lieutenant Lowe, who cleared the Captan ka Bazar, to the east of the Residency, of the enemy, and took 7 guns, but with the loss of Captain Hughes and 2 men killed, and 2 officers and 8 men wounded. On the 27th a second sortie was made in much greater force against the enemy's Garden battery to the S.W. of the Residency, which succeeded in destroying the battery, but with the loss of 10 killed and 11 wounded. On the 29th three sorties were made, in which Major Simmons, Captain M'Cabe, and a gentleman volunteer of distinguished gallantry, Mr Lucas, were killed, and about 50 others killed and wounded. On the 1st of October Colonel Napier made a very successful sortie, with trifling loss. In this manner such offensive operations as the smallness of General Outram's force would permit were continued till the 16th of November, when a determined and successful sortie was made in the direction of the Kaisarbagh to aid the advance of Sir C. Campbell, who, with a force of about 4000 men, had advanced from Cawnpore upon Lucknow. Simultaneously with the sortie Sir Colin reached the Secunderbagh, a palace on the E. of the city, and S.E. of the Residency, filled with sepoys, and protected by the fire from a large mosque, called Shah Nujjuff, a little to the N., and nearer the Residency. Here a terrific combat raged for three hours, when both places were at length taken, the latter chiefly by means of the 68-pounders of the naval brigade, commanded by Captain Peel. In the Secunderbagh alone 2000 corpses of the enemy were counted. On the 17th other defences of the enemy, between the Residency and the buildings just mentioned, were carried; and on the afternoon of that day, under a heavy fire, Generals Outram and Havelock advanced and met Sir C. Campbell. While Havelock was addressing his deliverers, his son was struck down close to him by a ball, but he continued his harangue, and did not turn to inquire the nature of the wound until he had concluded his address. In these operations 10 officers and 112 men were killed, and 33 officers and 312 men wounded. The long-beleaguered garrison of Lucknow was saved; but the numbers of the enemy were still so great that it was necessary to evacuate the Residency, and retire upon Cawnpore, without making any attempt to take the city. At midnight on the 22d of November the evacuation was noiselessly effected, most part of the effects belonging to the garrison being left behind; and so little was the retreat suspected by the enemy, that they continued to fire on the Residency long after it was deserted, so well had the operation been planned and carried out by General Outram. On the 25th of November General Havelock died of dysentery at Dilkusha, a palace and park to the S. of the city. On the 27th Sir C. Campbell received intimation from General Windham, whom he had left to defend Cawnpore, that his position had been attacked by overwhelming numbers of the rebels. Sir Colin therefore hastened back to Cawnpore with the utmost speed, and arrived just in time to save the bridge of boats from being destroyed by the enemy, who were in possession of the town, had completely surrounded General Windham, and had brought some guns to bear on the bridge. Their army, estimated at 20,000 men, consisted of the whole Gwalior contingent, comprising four batteries of artillery, two regiments of cavalry, and seven of infantry, and the forces under Nana Sahib and Koer Singh. On the 24th of November the vanguard had approached Cawnpore so close that General Windham resolved to advance to meet them, which he did on the 26th at the Pandu Nadee. After a sharp action he defeated them, and took 3 guns, losing 7 officers and 50 rank and file killed and wounded. Then, instead of retiring upon Cawnpore, he encamped in dangerous ground, amid thick jungle, where he was attacked next day, and, after a murderous conflict, driven into his intrenchments, the enemy occupying Cawnpore, which they plundered, setting fire to many of the public buildings. On the 28th Sir C. Campbell arrived, and extricated General Windham from his perilous position, surrounded by an infuriated enemy, without supplies, and having lost more than 300 of his best officers and men. After keeping the rebels in check until the sick, wounded, and non-combatants had been safely despatched to Allahabad, Sir Colin, on the 6th of December, after skilfully drawing the enemy from their position, advanced on them with irresistible fury, and overthrew them with great slaughter, capturing 16 of their guns, and putting them to headlong flight. He then despatched Brigadier Hope Grant with the cavalry and artillery, who, coming up with the fugitives as they were preparing to cross into Oude, took nearly all their remaining guns, and inflicted a further heavy loss upon them. Sir Colin's subsequent operations and his final victories at Lucknow will be found at the conclusion of this article.

Mutiny of 1857.

While the events above narrated were occurring at Delhi, Lucknow, and Cawnpore, numerous outbreaks and slaughters were taking place in other parts of India. On the 13th of May an outbreak occurred at Ferozepoor, on the left bank of the Sutlej, doubtless prompted by intelligence of the massacre at Meerut. At this station the crisis was manfully met by the British. The two regiments stationed here were the 45th and 57th native infantry. Upon being ordered to march from their cantonments, the 45th broke out into open mutiny. They were at once attacked by Her Majesty's 61st foot and the 10th Bengal light cavalry, which remained stanch, and few escaped from the place. The 57th, upon being reasoned with, gave up their arms. Ferozepoor is about 50 miles south of Lahore, the capital of the Punjab. At Meean Meer, the cantonments of Lahore, were quartered three regiments of native infantry, the 16th, 26th, and 49th, and the 8th light cavalry; and the whole of these, upon the arrival of tidings of the mutiny at Delhi, it was resolved at once to disarm. This being accomplished, the men were moving off to join the disaffected corps at Ferozepoor, but being intercepted by a movement of the British troops, they speedily returned to obedience. The whole business was managed with a degree of tact and discretion which reflects the highest credit on Sir John Lawrence, chief commissioner in the Punjab. Of the disarmed regiments at Lahore, one subsequently mutinied. This was the 26th native infantry, which, on the 30th of July, killed their commanding-officer, and then broke away. The fugitives were chased by the police and some of the new levies, and upwards of 500 were slain, or taken prisoners and executed. At Jullundur the 36th and 61st regiments mu-

Punjab.

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tinied on the 4th of June, and with a few men of the 6th light cavalry proceeded to Phillour, where they were joined by the 3d native infantry. These corps crossed the Sutlej and entered Loodiana, whence, being driven out by a detachment of Her Majesty's 8th foot, they made their way to Delhi. Symptoms of disaffection had also been manifested in the 51st and 55th regiments stationed at Peshawur, and some of the men had been discharged about the end of May. The 51st subsequently mutinied at Peshawur, and the latter at Huzzara. The 51st had been disarmed, and swift retribution overtook their treachery, nearly the whole regiment being cut up, or taken prisoners and executed. The 55th were attacked and broken, and a large number taken prisoners were executed at Huzzara. A remnant escaped, and took refuge with the predatory Affghans of the frontiers; but although at first received as friends, they are said to have been forcibly converted to Mohammedanism, and sold as slaves. At Mooltan two native regiments were disarmed by Brigadier Chamberlain. Sealkote, another military station in the Punjab, took an active part in the mutiny. The 35th regiment of native infantry, part of the illustrious garrison of Jellalabad, proceeding from Sealkote to Delhi, were believed to be wavering in their fidelity, and were disarmed. The 14th native infantry, which had mutinied at Jhelum, had been completely broken, with the loss, however, of 50 Europeans of Her Majesty's 24th regiment killed and wounded, besides 3 officers; but a small remnant escaping to Sealkote, were there joined by the 46th regiment, and a wing of the 9th light cavalry. The main body of these mutineers was overtaken by General Nicholson on the 16th of July, and completely cut up. In the meantime a moveable column had been organized by General Reed, in concert with Brigadiers Chamberlain, Cotton, Edwardes, and Nicholson; and mutiny, wherever manifesting itself in the Punjab, was speedily quelled and put down with a strong hand. Thus, not only did Sir John Lawrence suppress insurrection in his own province, but contributed also, in a great degree, to the success at Delhi, by forwarding large and timely reinforcements to the besieging army.

Allygurh.

Allygurh, an important post, as commanding the communications up and down the country, had been garrisoned by four companies of the 9th native infantry, the men of which had hitherto conducted themselves with steadiness. On the 20th of May these companies rose against their officers, who were thus compelled to abandon the station. A portion of the same regiment, which was quartered at Mynpoorie, mutinied on the 22d of May; but by the tact and admirable conduct of one of their officers, Lieutenant De Kantzow, the men were kept back from acts of violence, and finally quitted the station to join their comrades at Allygurh, *en route* to Delhi.

Nusseerabad.

At Nusseerabad, in the province of Ajmere, the 15th and 30th regiments of native infantry, and the 2d company of the 7th battalion Bengal artillery, mutinied on the 28th of May, and beat off with loss a portion of the 1st regiment of Bombay light cavalry (lancers), who gallantly charged the guns. In this engagement Captain Spottiswoode and Cornet Newberry were killed, and Captain Hardy and Lieutenant Jack wounded. Colonel Penney, commanding the 1st light cavalry, was killed by a fall from his horse. The rebels marched with colours flying and bands playing to Delhi. Subsequently a portion of the 12th Bombay native infantry mutinied at Nusseerabad on the 10th of August, and was disarmed.

Hansi, Hissar, and Sirsa.

On the 29th of May the Hurreeanah battalion and 4th irregular cavalry, stationed at Hansi and Hissar, to the north-west of Delhi, mutinied and massacred a number of Europeans. Many of the civil and military officers effected their escape. The gallant general, Van Cortlandt, who so signally distinguished himself in the Mooltan campaign, marching from the north-west, had two engagements with the rebels at Sirsa, defeating them in each instance with severe loss.

Mutiny of 1857.

At Bareilly the 18th and 68th native infantry, and the 8th irregular cavalry, rose *en masse* on the 31st of May. The outbreak appears to have been concerted for a fixed hour at a given signal. Brigadier Sibbald was killed. Many of the European residents and civil servants of the Company were massacred. Fortunately the ladies had quitted the station some days earlier for that of Nynee Tal. Among the victims were the two judges of Bareilly, Mr Raikes and Mr Robinson. These two gentlemen were arraigned before one of the native judges. It does not appear of what they were accused, but a mock trial ensued, when they were found guilty and beheaded. A number of half-castes and native Christians, amounting to no less than ninety individuals, were also dragged to the church and there butchered.

Bareilly.

Shahjehanpore.

Shahjehanpore, situated 50 miles to the south-east of Bareilly, was the scene of a more striking tragedy enacted on the same day. Here the Christian residents were at church, when the 28th regiment, after cutting down their officers, surrounded the edifice, and massacred the whole congregation.

Agra.

Agra also added to its celebrity by the heroic conduct of its garrison during the military revolt. An escort of treasure, proceeding from this place to Muttra about the middle of May, and consisting of two companies of the 44th and 67th native infantry, shot their officers, and decamped with the booty. Intelligence of the atrocity being conveyed to Agra, the two regiments on the 31st of May were ordered to parade and deliver up their arms. No hesitation was evinced by the men in obeying the mandate. From this time all was quiet for several weeks. But at the commencement of July the city was menaced by the 72d native infantry, a wing of the 7th light cavalry, and the 4th troop 1st battalion horse artillery, who, their ranks being swelled by bodies of malcontents, had marched to Futteypore Sikri from Neemuch, a cantonment distant 300 miles. At their approach the European inhabitants took refuge within the fort. The garrison there consisted of the East India Company's 3d regiment of European infantry, numbering, with the artillery, 650 men, besides 500 volunteers, foot and horse. On Sunday, the 5th of July, about 500 of this garrison,—it being known that the enemy were within 3 miles of the station,—boldly issued forth to confront the enemy. An obstinate battle ensued, and the rebels were dislodged from their position; when, the ammunition of the British force falling short, it was compelled to retreat. The English loss amounted to 49 Europeans killed, and 92 wounded. The spirit and gallantry displayed on the occasion seems to have had one good result, in securing the fort from attack or investment. About 5000 Europeans, including the garrison, had taken refuge within its precincts. The native troops stationed at Agra, consisting of the Kotah contingent and the Kerowlee horse, mutinied before the battle, and joined the rebels. Some weeks previous to these events, *i.e.*, on the 25th of May, a proclamation had been issued by the lieutenant-governor of Agra, offering pardon to all mutineers who should lay down their arms. This proclamation was disapproved by the government, and another substituted. Subsequently the rebels were dispersed. On the 24th of August a detachment from the fort, under Major Montgomery, consisting of about 200 men, encountered a strong body of the insurgents of the Doab, posted in the inclosed garden of Maun Singh, between Hatrass and Allygurh, and drove them back with great slaughter in the direction of Allygurh.

Benares.

At Benares, from the moment of the outbreak, great uneasiness had been felt, and when Colonel Neill reached that city with the 1st Madras fusiliers on the 3d of June, matters were in a very critical state. On the following

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day a report reached the city that the 17th regiment of native infantry had broken out into open mutiny, and attacked an escort of treasure at Azimgurh, situated 80 miles north of Benares. Upon this it was thought advisable to disarm the 37th regiment of native infantry, in which some excitement had been displayed. The regiment being ordered on parade, Colonel Neill called upon the men to lay down their arms. This was answered by a fire upon the British, which was immediately returned by the artillery and Europeans. The Sikh regiment and the irregular cavalry joined the mutineers. Upon observing the disaffection of the Sikhs, the artillery opened fire upon them, and broke them, though they charged up to the muzzles of the guns. The expulsion of the 37th from the lines was then effected, the mutineers taking the route of Jaunpore. After doing good service at Benares, Colonel Neill pushed on to Allahabad, where he arrived on the 11th of June, in time to save the fort. Here the 6th regiment of native infantry, which had rendered itself conspicuous by declarations of loyalty, mutinied on the 4th of June. The mutineers were joined by three troops of Oude irregular cavalry, and turned upon their officers, thirteen of whom they cut down. The remainder, with several civilians, took refuge in the fort, while the town was occupied by the insurgents; an influential Moulvie having set up his standard in the immediate vicinity, and gathered around him the elements of rapine and disorder. Colonel Neill found the place closely invested by the rebels. These he attacked on the 13th and 15th of June, on which last-mentioned day the enemy, beaten on all points, abandoned the city. On the 12th of July Colonel Neill was promoted to the rank of brigadier-general; and on the 16th, having handed over the command of the Allahabad garrison to Captain Hay of the 78th Highlanders, proceeded to Cawnpore to join General Havelock. The death of this gallant officer at Lucknow has been already noticed.

Gwalior.

The Gwalior contingent, a body of native troops paid by Scindia, but commanded by British officers, revolted on the 16th of June, in spite of the efforts made by the Maharajah, through whose aid alone the British officers escaped. From that time to the middle of November this powerful body of rebels remained inactive in the neighbourhood of Gwalior, being kept in check by Scindia, who called out his feudatories for that purpose. Several times a battle was on the eve of being fought, in which the superior discipline of the rebels would have probably given them the advantage. Had they succeeded, or had Scindia been less warm in the English cause, it cannot be doubted that the mutinous contingent would have agreed to the proposal of the Indore rebels and marched on Delhi, in which case the British besieging army would have been in imminent peril. Foiled, however, by the opposition of Scindia, the Gwalior contingent at length, about November, advanced towards Calpee, and thence, on the 24th of that month, marched on Cawnpore, where they engaged and defeated General Windham, but were subsequently routed, as mentioned above, by Sir Colin Campbell. They, nevertheless, still continued to hang about Calpee; and on one or two occasions skirmished sharply with the English advanced posts in that direction.

Indore.

Holkar's contingent rose on the 1st of July, and attacked the government British Residency, which they destroyed, and killed several officers and many persons connected with the English government. Most of the Indore officials and Europeans escaped to Sehore, from whence they arrived safely at Hoshungabad. The main body of these mutineers marched to Gwalior, where they vainly endeavoured to prevail on the Gwalior contingent to join them in an advance on Delhi. At last, on the 5th of September, they proceeded to Dholpore, about 30 miles from Agra, at the point where the road from Delhi to Bombay crosses the Chumbul. Fortunate it was that Delhi had fallen ere this great force of rebels could reach it. Colonel Greathed's column, which had been despatched towards Agra as soon as Delhi was completely occupied, after dispersing the Jhansi rebels in a sharp action at Bolundshuhur on the 27th of September, and blowing up the fort of Malagurh on the 29th, reached Agra on the 10th of October early in the morning. The weary troops had scarce begun to encamp when they were charged by the cavalry of the Indore rebels, whose guns opened on them at the same time. The English suffered some loss, and had a gun captured before they could form their ranks to resist this surprise. The Sikh horse were the first to charge the enemy, and they were followed by the 9th lancers, who charged in their shirt sleeves. The English guns then opened, and, after a fierce engagement of two hours, the rebels were routed with great slaughter, with the loss of thirteen guns and all their camp equipage. From the date of this overthrow Holkar's contingent never again formed a compact body. Indore itself was kept from joining fully in the rebellion, mainly through the zealous efforts of the young Prince Holkar, who throughout showed the most unshaken fidelity to the British. On the 15th of December the Malwah field force, under Brigadier Stewart, arrived in the city, and disarmed the malcontents, on many of whom summary justice was executed.

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Jhansi.

At Jhansi the troops, consisting of a wing of the 12th native infantry and some irregular cavalry, mutinied on the 5th of June, and a large number of Europeans, men, women, and children, were horribly murdered. The rebels marched off to Delhi. Upon the recapture of the city by the British on the 21st September, the Jhansi insurgents evacuated the place, and took the road to Bolundshuhur, where, on the 27th, as above stated, they were attacked by the pursuing column under Colonel Greathed, and completely routed.

Saugor.

At Saugor, in Central India, although the majority of the troops participated in the general spirit of mutiny, a remarkable instance of loyalty was displayed by one regiment. On the 3d of July, the 42d native infantry, and part of the 3d irregular cavalry, mutinied, and called upon the 31st regiment to join them. The latter regiment, deprived of its European officers, who had taken refuge in the fort, nevertheless behaved most loyally, drove the mutineers out of the station, retook a large signal gun and six elephants, which they restored to the authorities. The defeated rebels were, however, joined by large bodies of Boondelas and other marauders, and soon after completely invested Saugor, which remained in a state of siege and in extreme danger till the 3d of February 1858, when it was relieved by General Sir Hugh Rose, commanding the Nerbudda field force.

Dinapore.

Though the spirit of disloyalty was known to be all but universal throughout the Bengal army, three regiments of native infantry continued to be maintained in full force at Dinapore. These were the 7th, 8th, and 40th. A deputation of merchants had waited upon the governor-general, entreating that these regiments might be disarmed; but the reply had been, that the government had every confidence in the fidelity of the men. Shortly afterwards, however, the symptoms of mutiny became unmistakeable, and on the 25th of July the three regiments threw off their allegiance, and broke out in insurrection. At this time Her Majesty's 10th foot, and part of Her Majesty's 37th regiment, with an European field-battery, were quartered at Dinapore. Nevertheless, by the mismanagement of General Lloyd, in command of the station, and owing to his physical unfitness for his duties, the three mutinous regiments were allowed to cross the Soane river, and to escape with little loss to Arrah, distant twenty-five miles west of Dinapore. Here Mr Wake, the magistrate of the district, with 11 other Europeans and 45 Sikhs had taken refuge within a small bungalow, which had been previously fortified. The build-

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ing was forthwith surrounded by the insurgents. This being made known at Dinapore, a detachment composed of 350 men of the 10th and 37th regiments was despatched by boats for the relief of the little band; but being landed by night, under the direction of treacherous guides, the party fell into an ambuscade, and were driven back with a loss of more than half their number killed and wounded. The disaster was in some degree retrieved by the heroic defence of the besieged garrison. These succeeded in holding the rebels at bay during seven days, until the 8th of August, when, after the failure of the expedition from Dinapore, they were relieved by Major Vincent Eyre, of Caubul celebrity, who, with a detachment of 200 men and three guns from Buxar, dispersed a force of 3000 insurgents, headed by a native rajah, Kowur Singh, of Jugdeespore, with three pieces of artillery. The particulars of this romantic defence are thus given by Mr Wake, the magistrate of Shahabad:—"During the entire siege, which lasted seven days, every possible stratagem was practised against us. The cannons were fired as frequently as they could prepare shot, with which they were at first unprovided, and incessant assaults were made upon the bungalow. Not only did our Sikhs behave with perfect coolness and patience, but their untiring labour met and prevented every threatened disaster. Water began to run short—a well 18 feet by 4 was dug in less than twelve hours; the rebels raised a barricade on the top of the opposite house—our own grew in the same proportion; a shot shook a weak place in our defence—the place was made twice as strong as before; we began to feel the want of animal food and short allowance of grain—a sally was made at night, and four sheep brought in; and finally, when we ascertained beyond a doubt that the enemy were undermining us, a countermine was quickly dug. On the 30th, the troops sent to our relief from Dinapore were attacked and beaten back close to the entrance of the town. On the next day the rebels returned, and telling us that they had annihilated our relief, offered the Sikhs and the women and children (of whom there were none with us) their lives and liberty, if they would give up the government officers. August the 1st, we were all offered our lives, and leave to go to Calcutta, if we would give up our arms. On the 2d, the greater part of the sepoys went out to meet Major Eyre's field force, and on their being soundly thrashed, the rest of them deserted the station; and that night we went out, and found their mine had reached our foundations, and a canvass tube filled with gunpowder was lying handy to blow us up; in which, however, I do not think they would have succeeded, as their powder was bad, and another stroke of the pick would have broken into our countermine. We also brought in the one gun which they had left on the top of the opposite house. During the whole siege, only one man, a Sikh, was severely wounded, though two or three got scratches and blows from splinters and bricks." The mutineers, driven from Arrah, retreated in the direction of Jugdeespore, whither they were pursued by a detachment of the 10th foot. Here the men of that regiment gloriously avenged the slaughter of their comrades at Arrah. After a contest which lasted for upwards of two hours, Jugdeespore fell into their hands. No less than 400 of the rebels were cut down, and the remainder completely routed. General Lloyd being removed from his post, Sir James Outram succeeded to the command of Dinapore, but shortly after moved up towards Oude.

Jubbulpore.

Among the latest revolts was that of the 52d native infantry, which mutinied and quitted Jubbulpore, a station 111 miles S.E. of Saugor, with the view of effecting a junction with the Dinapore rebels. The insurgents were met near the fort of Saugor by the column of Madras troops from Kamptee, and defeated, with a loss of 150 killed. Lieutenant Macgregor, who had been detained by the regiment as a kind of hostage, was murdered by the rebels. His body was found by the British covered with wounds.

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At the small town of Nagode or Nagound, on the road from Saugor to Allahabad, and about 30 miles to the N.W. of Rewah, was stationed the 50th Bengal native infantry. This corps mutinied, but without slaughtering its officers, not long after the outbreaks at Saugor and Jubbulpore; and thus the circle of rebellion was completed in Bundelcund. The rajahs of Saugor and Shahgurh, and the rani of Jhansi, aided the insurgents with all their power. The rajah of Rewah remained faithful, though his troops were disaffected.

Nagode.

On the 21st of August a detachment of the Jodhpore legion, stationed at Aboo, rose, plundered the bazaar, and attempted to murder some invalids of Her Majesty's 83d regiment, but were repelled from their barracks with loss. They wounded Mr A. Lawrence, son of General G. Lawrence, and, descending the mountain, plundered the village of Anadra at the foot of it, and then proceeding to the stations where the other parts of the legion were, induced them to join. On the 1st of September General Lawrence marched from Ajmere to meet them, and on the 18th came upon them at Awah, and succeeded in driving them from their position outside the town, but finding this too strong to be attacked, was compelled to retire. Here Captain Monk Mason, who had pushed on from Palee to join General Lawrence, was killed in the attempt. About this time the chiefs of Dhar, Mundesore, and Amjheera, joined in the rebellion; and on the 19th and 20th of September a sharp action was fought at Neembhera, about 20 miles N.W. of Neemuch, in which the 12th Bombay native infantry, and the 2d Bombay cavalry, distinguished themselves. The place was taken with the loss of one European killed, and 16 natives killed or wounded. The Jodhpore legion was subsequently completely routed at Narnoul, 86 miles S. of Hansi, by Colonel Gerrard, who was killed in the action. Five officers were wounded, and the total of killed and wounded was 70.

Aboo.

At Kotah, the capital of the Rajpoot state of that name, situated on the right bank of the Chumbul, 195 miles S.W. of Agra, the forces of the rajah, consisting of 2140 infantry, 710 cavalry, and 600 artillerymen, rose against his authority, and in rebellion against British supremacy, on the 15th of October, and murdered the political agent, Major Burton of the 40th Bengal native infantry, with his two sons. They then plundered the Residency and set fire to it.

Kotah.

Besides these principal outbreaks, many lesser risings and mutinies of single corps, or detachments of corps, took place in various parts of India. Thus the Ramgurh battalion mutinied near Sherghotty, and on the 29th of September were met and routed by Major English with a detachment of the 53d regiment and some Sikhs. The 32d native infantry rose at Deogurh in the south-west districts, and killed Lieutenant Cooper, Mr Ronald, and some others; the 34th at Chittagong, and the 73d at Dacca and Julpigoree, also mutinied so late even as November 1857, but the defection of these corps produced only local disturbance, and added little or nothing to the danger and magnitude of the general revolt. In the meantime, the Madras army, with the exception of the 8th cavalry, which refused to proceed on service to Bengal, and was consequently disarmed, and a few irregular troops at Nagpore, continued faithful and aided greatly in the suppression of the revolt. The principal native ruler in Southern India, the Nizam, threw the whole weight of his influence into the scale in favour of the British; and his minister, Salar Jung, a nobleman of European energy, courage, and abilities, crushed a desperate attempt of the fanatical Rohillas to raise the standard of rebellion at Hyderabad. In the Bombay army, where there were 15,000 soldiers, recruited from Oude and the adjacent provinces, the case was different. On the evening of the

Mutinies in other parts.

Mutiny of 1857.

31st of July, 167 men of the 27th Bombay native infantry rose at Kolapore, in the South Mahratta country, and murdered three of their officers, and carried off 37,000 rupees from the treasury. They were shortly afterwards attacked by Lieutenant Kerr, with a body of the South Mahratta irregular horse, and dispersed or destroyed. The fugitives perished in the jungles of want, or were killed by the villagers. On the 10th of August a trooper of the 1st Bombay lancers attempted to raise an *émeute* at Nusseerabad, and was for a time protected by the 12th native infantry, but at length shot. About the same time a small part of the 2d Bombay cavalry mutinied at Neemuch, and were not overpowered without a struggle, in which four Europeans lost their lives. Plots were also discovered in the 2d grenadiers at Ahmedabad, and the 29th native infantry at Belgaum; and on the 20th of August the havildar major of the latter regiment, and some others, were executed. At Bombay the 10th native infantry were discovered to be in a disaffected state; and a soldier of that corps, and one of the marine battalion, were blown from guns. But it was in Sindh that the most extensive conspiracy was formed; and but for the fidelity of Jacob's horse, and the admirable management of the commissioner, Mr Frere, the whole of that province would have been in a blaze. At Kurrachee the 21st Bombay native infantry were disarmed, and a considerable number of sepoys executed; at Shikarpore and Hyderabad there were attempts at a rising; and at the former place the Bengal artillerymen seized the guns, and kept up a fire on cantonments for some time. These particulars suffice to prove the alarming state of India when the European reinforcements from England began to arrive. It remains now to show how these were made available for the extinction of the revolt.

Measures for suppressing the revolt.

Between June the 18th and the end of November 1857, ninety-four large transports were despatched from England, having on board 34,481 European soldiers to reinforce the royal army in India. In addition to these, 900 men were despatched overland; and several regiments were drawn from the Cape, Ceylon, and the Mauritius, and also from the China expedition, whence also was furnished a formidable naval brigade, the men of which served 68-pounder guns with terrible effect in the storming of Lucknow. In the beginning of November the bulk of these reinforcements began to arrive, and in the first fortnight of that month 8000 men were landed at Calcutta alone. Thus along the Ganges a stream of reinforcements was constantly flowing up, enabling the commander-in-chief to reduce Lower Bengal to order, garrison the chief places, and prepare a powerful army for the capture of Lucknow and the complete conquest of Oude. At the same time Sir J. Lawrence was actively engaged in levying new Sikh troops and despatching them to the south; while Jung Bahadur, the regent of Nepal, sending forward several thousand Gorkhas to the aid of the British, prepared to descend from the hills into Oude with 10,000 more. At Madras and Bombay, as fresh European regiments arrived, those already in the presidencies were pushed up towards Central India, and there formed into columns, which gradually swept the rebels towards the east, and co-operated with the columns from the Delhi and Punjab armies, which, advancing southward, cleared the Doab and Rohilcund, and drove the insurgents into Oude, where they were stopped by Sir C. Campbell and the main army. Turning to the operations of the subsidiary columns during the close of 1857, and taking that of Colonel Greathed first, it may be briefly noticed, that after the defeat of the Indore rebels on the 10th of October, this force halted a few days at Agra, and reached Mynpooree, 71½ miles to the east of Agra, on the 19th; and on the day previous Brigadier Grant took command from Colonel Greathed. The guns and treasure of the rajah, who had fled with the rebels, were here captured, and the fort was blown up. On the 23d the column arrived at Kanouj, and there falling in with a body of the Delhi fugitives, killed 200 of them, and captured five guns, with the loss of one officer and two privates wounded. On the 26th the column reached Cawnpore, whence, its losses being recruited by fresh troops, and having been made up to 3460 men, with twenty guns, it moved on towards Lucknow, and arrived at Nawabgunge, near that city, on the 1st of November. From this date its operations merge in those of the main army.

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In the meantime, the districts west of Delhi were swept by a column under Brigadier Showers, who, on October the 2d, captured Rewaree, 50 miles S.W. of Delhi, the town of a rebel rajah, who fled, leaving twelve guns loaded on the ramparts of his fort. On the 12th Brigadier Showers reached Jhajhar, once the capital of the adventurer George Thomas, but now of a rebel nawab, who was made prisoner on the 17th, and subsequently hanged at Delhi. The column then moved to Dadree, cutting to pieces some small parties of rebels on the way, and thence to Kanound, where fourteen guns and considerable treasure and stores were taken. On the 31st of the same month a detachment of this column cut up a body of Mewatties on the heights near Sona, in the Goorgaon district. The column returned to Delhi on the 9th of November, and immediately after moved out again to Meerut, *en route* for Bewar.

Delhi column.

From Madras a strong column having assembled at Kurnool under Brigadier Whitlock, moved upon Jubbulpore, and on the 15th of December advanced from that town into the Saugor territory, quieting the disturbed districts as it proceeded, and sending on two regiments of cavalry to clear the way to Benares. The advance of this column was greatly facilitated by the brilliant successes of Captain Osborn, the political agent at Rewah, and Lieutenant-Colonel Hinde, who, with the forces of the rajahs of Punnah and Rewah, and some levies raised in Bundelcund, defeated several bodies of insurgents, and captured the strong fort of Bijrajooguih, the killadar of which place, and ninety-three other prisoners, were shot by command of Brigadier Whitlock. Simultaneously almost with the successful operations of the last-named officers, an alarming outbreak of the wild tribes in Sumbulpore, a large expanse of jungly country directly south of the region in which the column of Brigadier Whitlock was moving, was put down by Major Bates of the 40th Madras native infantry, and Captain Wood, commanding a squadron of the Nagpore irregular cavalry. On the 30th of December Captain Wood, with 73 horsemen and 200 infantry of the 40th native infantry and Ramgurh battalion, encountered a body of the rebels near Sumbulpore, and killed fifty-three and dispersed the rest. Captain Wood, who killed three of the enemy with his own hand, was wounded, with Dr Winslow and nine privates. These rebels had previously murdered Dr Moore not far from the spot where they were defeated. Another body of insurgents was shortly afterwards routed with great slaughter by Major Bates in the same district. Madras troops were likewise successfully engaged some weeks later in suppressing a rebellion raised by the rajah of Shorapore, a small principality in the S.W. angle of the Nizam's territories. On the 7th of February the troops of the rajah were defeated near his chief town by a small Madras column, with trifling loss to the English; but Captain Newbery of the 8th Madras cavalry was killed, and Lieutenant Stewart of the same corps wounded. Shorapore was occupied next day by Colonel Malcolm, with the South Mahratta horse; and the rajah himself was made prisoner at Hyderabad, whither he had fled.

Madras army.

From the Bombay side a column called the Malwah field force, consisting of the 14th light dragoons, Her Majesty's 86th foot, the 3d Bombay cavalry, the 25th native infantry, some Bombay artillery, and a strong force of the Nizam's

Bombay army.

Mutiny of 1857.

contingent, had been organized under Brigadier Stewart of the 6th native infantry, for operations in Central India. On the 22d of October this column defeated a body of rebels near Dhar; and on the 1st of November took that strong place, the fort being one of the strongest in India. After the battery had opened for four days, an advance was made to the breach, when the fort was found to be evacuated. A treasure of nearly half a million was here captured. On the 8th Brigadier Stewart marched north towards Mehidpore, when an army of rebels under Heera Singh, formerly a jemidar in the Nagpore cavalry, had, with the aid of the Mehidpore contingent, which mutinied as they approached, committed great havoc, and killed Major Timms, Captain Mills, Dr Carey, and several other Europeans, as well as 150 of the contingent who remained stanch to the British. On the 13th Major Orr, with the 1st, 3d, and 4th Nizam's cavalry, attached to the Malwah field force, came up with Heera Singh, and made a most brilliant and successful charge, retaking all the guns and stores just captured from the Mehidpore contingent. The rebels were pursued to a village ten miles from Mundesore, where their supports showed themselves in great strength. On the 21st the whole column, of which Major Orr's cavalry formed part, was attacked by the Mundesore rebels, numbering about 8000 men, who were driven back into the town with heavy loss. On the 23d the column defeated Heera Singh at the village of Gooraria. The 14th dragoons captured five guns on the enemy's left centre. Lieutenant Redmayne of that corps was killed, and seven officers were wounded, and 68 rank and file killed and wounded. On the night of the 24th the rebels evacuated Mundesore. These rebels had besieged Neemuch for the three weeks previous to the arrival of the Malwah field force, and on the 21st had attempted to carry it by escalade, but were repulsed with loss. The casualties on the English side were two European officers and four sepoys wounded. The 12th Bombay native infantry here particularly distinguished themselves. In a battle fought, however, at Jeerun, near Neemuch, on the 24th of the previous month, the English garrison of that town had sustained severe losses. On that occasion Captain Tucker of the 2d Bombay cavalry, and Captain Reade of Her Majesty's 83d foot, were killed, five officers were wounded, and other casualties were numerous. The Malwah field force now made a long halt at Mundesore, where many of the rebels were executed. On the 2d of December it moved south to Indore, which it reached on the 15th; and next day Sir R. Hamilton, the governor-general's agent for Central India, and General Sir Hugh Rose, arrived there, and Holkar's mutinous troops were forthwith disarmed, and numerous executions took place. General Rose having gained the chief command of this column, which was now called the Nerbudda field force, proceeded to Sehore, a town in Bhopal, 132 miles S.W. of Saugor. Arriving here on the 10th of January 1858, he disarmed the mutinous Bhopal contingent stationed at Sehore, and caused 150 of them to be executed. He had now with him the 14th and 17th dragoons, and the 3d Bombay lancers, Her Majesty's 86th foot, the 3d Bombay European regiment, and a very powerful force of artillery, sappers and miners, and engineers. On the 26th the general laid siege to the strong fort of Ratgurh, which was taken on the 29th, many of the rebels escaping down the precipitous rocks. The day previous an insurgent force which attempted to relieve the garrison was defeated, and driven across the river, by Captain Hare with the Hyderabad contingent. A pretender, who had assumed the title of a prince of the house of Timour, named Muhammed Fazl Khan, was here taken and hung with another chief over the gate. On the 30th Sir H. Rose marched for Saugor, and at the first stage from Ratgurh, drove a body of rebels from some difficult ground. Here Captain Neville of the royal engineers, aide-de-camp to Sir H. Rose, was killed. On the 3d of February Sir Hugh reached Saugor and relieved the garrison, which had been besieged since July of the previous year. Twenty rebels were executed here.

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On the 3d of March Sir H. Rose, moving on Jhansi, forced the Mudianpore Pass, with the loss to the British of 20 killed and wounded.

Early in January 1858 a strong column, under Brigadier Roberts, prepared to move from Deesa in Gujerat into Rajpootana. On the morning of the 6th, 200 men of the 10th Bombay native infantry, 100 of Her Majesty's 95th regiment, 2 guns, 30 men of Captain Aitken's battery, and 20 of the royal sappers and miners, under command of Major Raines of the 95th, went forward to attack the village of Rowah, 9 miles from Deesa. It was found strongly fortified, but the infantry gallantly stormed it. Three British officers were wounded, and several men. Gold and silver coins to the value of L.5000 were found among the ruins of the village. On the 10th Major Raines, having sent back his sick and wounded to Deesa, and having received reinforcements, advanced towards Awah, his column now consisting of the 8th hussars, 1st Bombay lancers and 2d cavalry, Her Majesty's 72d Highlanders, and 96th and 51st regiments, with a detachment of the 83d and the royal engineers, the 1st and 2d native infantry, Captain Aitken's battery, 2 troops of horse artillery, and a siege train. On the 19th the column was joined at Jaitpoora, 2 miles from Awah, by two companies of the 83d, a battery of foot artillery, 600 Sindh horse, two squadrons of the 1st lancers, and part of the 12th native infantry, under Colonel Holmes of the latter regiment, who took command of the whole force. On the night of the 23d this column captured Awah, one of the strongest towns in Rajpootana, taking 16 guns and 170 prisoners, of whom 25 were executed forthwith. On the 1st of February General Roberts marched from Deesa to join Colonel Holmes, having with him some sappers and miners, a wing of the 9th regiment, and some of the 2d cavalry, and having effected a junction, the whole column, 7000 strong, with 30 guns, marched towards Kotah, through the pass of Bharoondurrah.

Operations of the main army.

In the meantime, the commander-in-chief was busily engaged in preparing for the final reduction of Oude and the capture of Lucknow. After the complete route of the Gwalior rebels, and their flight across the river into Oude, or westward to Kalpee, Sir C. Campbell despatched a column under Brigadier Walpole to clear the Lower Doab, and make its way to Etawah. He himself, leaving three regiments at Cawnpore with instructions to put that place in a state of defence by digging rifle-pits, throwing up earthworks, and levelling buildings that might yield cover to an enemy, moved with the main army upon Furruckabad. This place, the capital of the district so called, and distant from Agra 90 miles, from Lucknow 95, is on the left bank of the Ganges, while the British cantonment of Futtygurh lies about 3 miles to the west, on the right bank of the river. Both places were occupied in great force by the rebels; and the nawab had taken a leading part in the insurrection, and by the murder of a great number of Europeans had made himself only less infamously prominent than Nana Sahib. As Sir C. Campbell approached, the nawab received an accession of strength from Etawah, the rebels at that place deserting it on the 29th of December, when Brigadier Walpole entered, and flying to Furruckabad. On the 20th of January Sir Colin came to a place one march from Furruckabad, where a bridge over the Kalee Nadee had to be repaired. The working parties were attacked by about 5000 rebels, who were, however, quickly put to flight, with the loss of all their guns, seven in number. Here a most gallant officer, Lieutenant Younghusband, of the 5th Punjab

Mutiny of 1857.

cavalry, was wounded mortally, and Lieutenant Maxwell, of the Bengal artillery, severely. The next day Sir Colin occupied Furruckabad, which was evacuated by the enemy, the nawab leaving his guns and stores behind him. A column from Delhi, under Colonel Seaton, arrived at Futtygurh at the same time. On the 29th of December Captain Hodson, of the irregular cavalry, had brought despatches from this column to Sir Colin, riding 90 miles across a country overrun with rebels. In this hazardous exploit three of his escort were killed, and a few wounded. On the 13th of January Brigadier Walpole, with his brigade, was moved forward to repair a bridge over the Ram Gunga; and as a powerful force of the enemy assembled to oppose him on the opposite bank, reinforcements were sent out to him on the 15th. On the 26th a sharp action was fought between a force under Brigadier Hope, and 5000 of the rebels, with four guns, who had crossed the river at Mhow, 18 miles from Furruckabad. Captain Hodson was severely wounded, and his second in command, Lieutenant Macdougal, killed. Captain Steel of the 9th lancers, and Lieutenant Gough of the 3d Bengal cavalry, were also wounded; and 13 men and Dr Fairweather of the 4th Punjabees, and 10 men of Her Majesty's 53d regiment, were killed or wounded by the explosion of one of the enemy's tumbrils. On the 1st of February the commander-in-chief, leaving a brigade to watch the Rohilcund rebels, broke up his camp from Futtygurh and descended upon Cawnpore. He himself rapidly passed through the place on the 4th, reached Allahabad on the 8th, where he had an interview with the governor-general, who was now on his way to the seat of war. The same night he returned to Cawnpore, where, till the beginning of March, he was employed in superintending the concentration of stores and troops for the advance on Lucknow. On the 3d of February the 88th regiment, with two guns and some Sikh horse, despatched to watch the Kalpee rebels, arrived at Bhognipore, 5 miles from Kalpee. Next morning they were attacked by the rebels from the latter place, consisting of part of the Gwalior contingent, and the 32d and 40th native infantry. The enemy first attacked the picquet of Captain Thomson, who commanded the Sikh horse. He bravely held his ground until reinforced, when the enemy were repulsed, and pursued to within a mile of Kalpee. Captain Thomson was wounded, and six men, the former severely. On the 7th of February Mr A. Hume of the civil service, with 400 matchlock-men, and a corps of irregular cavalry under Captain W. Alexander and Mr Maconochie, moved out from Etawah 22 miles to Anundram, where about 800 rebels occupied a strong position with one gun. Mr Hume gallantly led the storming party, and put the rebels to flight, who were then sabred by the cavalry. The enemy left 25 dead on the field; their gun was taken, and 6 prisoners, who were hanged. Mr Hume's party lost 38 killed and wounded. About a month previous to this the Bareilly rebels despatched three columns, two to attack Nynee Tal, and the third to overrun the Saharunpore districts. On the 10th of February one of these columns was encountered by Colonel M'Causland from Nynee Tal, with the 66th Gorkhas, 200 cavalry, and 2 guns, near Buteree. The enemy lost 3 guns, and had 250 men killed. The British loss was 35 killed and wounded, including 2 officers wounded. The third rebel column, led by the Nawab of Najeebabad, crossed the river at Kunkhal, near Hurdwar, on the 10th of January, and were immediately attacked by Captain Boisragon with 100 Gorkhas, a few Sikhs, 10 Europeans, and 2 guns. The rebels fled in confusion on being charged by the Gorkhas in flanks, and by the Sikhs, led by Mr Melville of the civil service, in front; and the Moyapore dam being suddenly opened by Captain Drummond, of the canal department, as they were fording the stream on their retreat, great numbers of them were drowned. The nawab himself was wounded, and his nephew fell by Captain Boisragon's own hand.

Mutiny of 1857.

It is requisite here, in order to complete the view of operations at this time, to revert for a moment to the Bombay presidency, where the Bheels in the Ahmednugur and Khandesh collectorates, and adjoining districts, and along the Sautpoora Mountains, had risen in arms so early as September 1857. On the 8th of October a number of them, estimated at 1500 men, had posted themselves on a hill at Sinnore, 20 miles S. of Nassuk. Here they were on that day attacked by Lieutenant Henry, superintendent of the Ahmednugur police, who was killed, and his party repulsed with severe loss. On the 29th of the same month, Raghujee Bhangria, a Bheel chief, passed through the Ahmednugur districts, plundering and burning. During the end of November and December the Bheels, under Khajja Singh, in great force, lined the Sautpoora Hills, near the Sindhia Ghat, and are said to have carried off plunder from the adjacent villages to the amount of L.140,000. Towards the end of January the Bheels of Chandore were attacked by Captain Montgomery, superintendent of the Ahmednugur police, in a dense jungle, 12 miles S.E. of that place, with indifferent success. He gallantly led his men three times to the charge, but was himself badly wounded, and obliged to retire. Lieutenant Stuart of the nizam's infantry was killed; Lieutenant Davidson of the 19th native infantry, and Lieutenant Chamberlain of the 26th native infantry, wounded,—the former dangerously. On the 19th of February another engagement took place near the same spot, at Mahadeo Donger, when Captain Pottinger defeated the insurgent Bheels, and took many prisoners.

Mutiny of the Bheels.

The Gorkha allies.

Returning to the operations in Oude, it is requisite, before describing the first advance of the commander-in-chief from Cawnpore, to give a brief summary of the movements of the Gorkha forces despatched by Jung Bahadur to the aid of the British, and subsequently supported by a powerful column under his own command. The Nepal chief had, soon after the outbreak, volunteered his assistance to the governor-general, but his overtures were at that time rejected. In July, however, 3000 Gorkhas had reached Goruckpore; but owing to the masses of rebels which surrounded them, they retreated from that place, with all the Europeans belonging to the station, on the 13th of August, towards Azimghur. At Gujhaba, 35 miles from Goruckpore, they were attacked by some thousands of rebels under Mohammed Hoossain, but soon repulsed their assailants, killing 150, and taking many prisoners, who, with two exceptions, were all put to death. The Gorkha loss was 2 killed and 7 wounded. Having arrived at Azimghur, which they found plundered by the rebels, they halted there, and on the 20th of September sent out 1000 men under Captain Boileau to attack a party of insurgents at Nundowlee, belonging to the Rajah of Attroniah. The Gorkhas were completely successful, and took three brass guns at the point of the bayonet, killing 100 of the enemy, and having themselves but 16 wounded. Jung Bahadur at this time sent a reinforcement of two regiments to the hill stations of Almora and Nynee Tal. Major Ramsay, with 150 Gorkhas, 25 irregular horse, and 30 gentlemen volunteers, before the above reinforcements arrived, attacked a body of 800 rebels advancing on Almora from Bareilly, and killed upwards of 100, losing only 1 risaldar killed, and 1 Gorkha wounded. On the 30th of October Colonel Wroughton, with 500 men of Her Majesty's 10th foot, 1100 Gorkhas, and some guns, drove a body of 5000 rebels, with 4 guns, from a position at Chanda. The Gorkhas gallantly captured the guns, and killed 400 of the enemy, losing 13 of their own men killed, and 60 wounded. The same Gorkhas had, on the 19th, defeated Hasan Yar Khan at Kudwa. In that action Messrs Jenkinson and Carnegy of the civil service greatly distinguished themselves, and killed 7 of the enemy.

Mutiny of 1857.

Towards the end of November the rebels from Lucknow pushed heavy columns to the south; so that the Gorkhas were compelled to again evacuate the Goruckpore district and Azimghur. On the 2d of December Jung Bahadur arrived at Segowlee, in the plains, having with him 9000 regular Gorkha troops and a multitude of irregulars.

On the 19th of December the *Calcutta Gazette* announced that Jung Bahadur was entering the plains of Hindustan to co-operate with the British troops in the restoration of order in the British provinces. Brigadier-General Macgregor was appointed to accompany the Nepaulese chief; and a strong brigade under Colonel Franks was organized at Benares to co-operate with him by advancing in the direction of Jaunpore and Azimghur. Her Majesty's 97th and 20th foot, with a wing of the 10th regiment and some royal artillery, formed the nucleus of this force. On the 6th of January Jung Bahadur, with 14 regiments of infantry and 4 batteries of artillery of 6 guns each, took Goruckpore. The enemy's position was strong, but their resistance feeble. They lost 7 guns, and had 200 men killed; while the Gorkha loss was 2 killed and 7 wounded. Previous to this action a column of the Goruckpore rebels had been defeated at Sobanpore, 5 miles S.E. of Majhowlee, and 40 from Goruckpore, by Colonel Rowcroft with the naval brigade (about 160 men) and two Gorkha regiments. The rebels lost a gun, and had 200 killed; while there were but 4 wounded in Colonel Rowcroft's force. In the meantime the enemy had shown themselves in such force near Azimgurh, that Colonel Longden, commanding there, had been compelled to retire. By the 22d of January Jung Bahadur's van had reached Belwa Bazar, on the Gogra, opposite Fyzabad; and Colonel Franks' column had been swelled by 4000 Gorkhas, some Madras troops, Sikhs, 200 sailors, while his artillery amounted to 24 guns. On the 4th of February the advanced troops of the Gorkha main army attacked and dispersed the rajah of Gondah's army near Fyzabad, with the loss to themselves of only 1 killed and 2 wounded. But Brigadier Franks was now rapidly pushing forward; and on the 19th of February he defeated at Chanda two armies of rebels, one of 8000 men, the other of 11,000. The loss of the enemy was very heavy. On the 23d the same officer gained a still more decided victory, killed 1800 of the rebels, and captured their standing camp and 20 guns. The British loss in the three actions was 2 killed and 16 wounded. Many rebel sepoys of the 13th, 15th, 20th, and 40th native infantry were killed in these engagements. Both the column of Brigadier Franks and that of Jung Bahadur joined the commander-in-chief at Lucknow without further serious opposition.

Capture of Lucknow, and close of the revolt.

In the meantime, Sir J. Outram had repulsed incessant attacks on his post at Alumbagh, just on the outskirts of Lucknow, which he held with a fine division of 5000 men, composed of the 1st Madras fusiliers, the 5th fusiliers, the 75th, 78th, and 90th, with Brusier's Sikhs, Olphert's and Maude's batteries, some Madras sappers and miners, and the volunteer cavalry. To these regiments belongs the glory of maintaining the post of honour, and taking the lead in the final triumph at Lucknow. They were several times attacked at Alumbagh by immense masses of the enemy, and always repulsed them with terrible loss. On the 22d of December they took from the rebels 4 guns, an elephant, and great stores of ammunition. On the 12th and on the 16th of January they routed a mass of 30,000 men, which advanced on all sides of them. On February the 21st the rebels came out again in vast numbers, having sworn on the Koran to conquer or die. They formed in the shape of a crescent, and as the horns of their immense line began to converge on Alumbagh, General Outram attacked each extremity of it. They gave way almost at once, leaving 500 dead on the field; while the British had only 6 wounded. On the 25th they made another and a final effort, the begum and her son coming out on elephants to witness the conflict, which ended still more disastrously for them than the preceding. These successes were a presage of the easy reduction of the city, which fell on the 19th of March. Sir C. Campbell had been detained at Cawnpore longer than was expected by the non-arrival of the siege train from Agra. At last, on the 10th of February, an extra bridge having been thrown over the Ganges from the Cawnpore side, the passage began. Such, however, was the prodigious number of men and animals, that it was many days ere they had crossed. The whole road from Cawnpore to Alumbagh was lined with troops and baggage-cattle, among which were 16,000 camels. The actual numbers of Sir C. Campbell's main army were—infantry, 11,442; cavalry, 3961; artillery, 1669; naval brigade, 331; sappers and miners, 1970;—grand total, 19,373. Thus, with Outram's and Franks' divisions of 5000 men each, and Jung Bahadur's army of 10,000 Gorkhas, the whole force arrayed against Lucknow fell little short of 40,000 men, with 180 guns; and it may justly be said that an array so formidable and so well appointed never was seen in Hindustan.

Mutiny of 1857.

On the 6th of March, Sir C. Campbell having arrived a few days previously, General Outram, with 5000 men and 30 guns, crossed the Goomtee, and took post to the E. of the city, pushing his reconnoissances to the S., and after repulsing an attack, bivouacked on the field of Chinhutt, where Sir H. Lawrence was so disastrously defeated. On the 7th Sir J. Outram despatched General Hope Grant with 2000 cavalry to the N.E., to make a reconnoissance, and during his absence the enemy made a second and more serious attack. On the 9th Sir James turned the enemy's first line of works, which, though constructed with great care and skill by the revolted sappers and miners from Roorkee, were by a grave mistake made without protections from a flanking fire. In consequence, Outram's guns enfiladed the whole line, and enabled General Lugard's division, on the 10th, to carry the Martiniere and adjacent works on the S. of the city; and shortly after, the whole left of the enemy's earthworks, to within 800 yards of Banks' house. On the 10th this latter post was taken, and on the 11th the same division carried the begum's palace, which had been fortified in a way to make it defensible against a whole army. Here 600 bodies of sepoys of the 22d, 38th, and other regiments, were counted; and General Lugard lost about 100 men of his division in killed and wounded; among them Captain Hodson, the capturer of the King of Delhi, and well-known commander of irregular horse. On the same day Jung Bahadur joined with his Gorkhas. A severe struggle now took place in the direction of the Moosa Bagh, to the N.W. of the city; and here Captain Cooper of the engineers, Captain Moorsom of Sir J. Outram's staff, and many other gallant men, fell. On the 13th Sir Colin took the Imambara, and opened a tremendous fire on the Kaiser Bagh, the walls of which were shivered to pieces. On the 14th General Outram carried the town between the iron bridge and the Residency; and thousands of the enemy began now to stream out of the city, taking the road to Rohilcund. On the 16th the Muchee Bhawan and Great Imambara were captured; and on the 18th the Gorkhas carried a very strong position in front of Alumbagh. A detachment of these troops brought in Mrs Orr and Miss Madeline Jackson, who had been prisoners in the hands of the rebels since the advance of General Havelock. On the 19th the whole city was in possession of the British; and though many thousands of the rebels escaped, and a desultory warfare ensued, the close of the great revolt may be dated from this epoch. (E. T.) (E. B. E.)

North-West Territory ‖ Norway.

NORTH-WEST TERRITORY. See HUDSON'S BAY TERRITORY.

NORTHWICH, a market-town of England, in the county of Chester, on the left bank of the Weaver, near its confluence with the Dane, 15 miles N.E. of Chester, and 155 N.W. of London. It has an old-fashioned appearance, and contains many ancient buildings. The church, which is large, is remarkable for its semicircular chancel and curiously carved roof. There are also places of worship for Independents, Baptists, Wesleyan and Primitive Methodists, and several schools. Northwich is chiefly important for its salt mines and brine springs, the former of which have been worked since the seventeenth century, and are believed to be the richest salt mines in the world. The brine springs, however, are now more extensively used, and are calculated to yield from 300,000 to 400,000 tons of salt annually. This forms the principal article of trade in Northwich, being conveyed to Liverpool by the Weaver and Mersey, on which about 300 vessels are employed in this business. Ship-building, brick-making, iron and brass founding, brewing, and other avocations, are carried on here; and fairs are held three times a year. Pop. (1851) 1377.

Norton Chipping ‖ Norway.

NORTON-CHIPPING. See CHIPPING-NORTON.

NORWAY.

History.

NORWAY is an extensive country in the north of Europe, united with Sweden under one king. All the territory which is now comprised by Norway and Sweden, was designated *Scandia* by the ancients. Pliny calls it *Scandia insula*, an appellation which derives its origin from the circumstance of the Romans, in the time of their great naturalist, being only acquainted with that part of the country called Skanen or Skonen, the little information which they possessed being obtained from some Germans. This is the ancient province of Schonen or Scania, the most southerly of Sweden. The name was afterwards changed to Scandinavia, which has been called the "store-house of nations," but without any just title to such a distinction. It seems now quite certain that Scandinavia was not the native country of the Scythians or Goths, but that they migrated from Asia to Europe. The fact of Pliny having designated Scandinavia as an island of considerable although uncertain magnitude, has also given rise to some discussion. To the imperfect knowledge of geography which the ancients possessed may reasonably be attributed their mistaken notion as to the insular position of these countries.

Origin of the name.

But our present purpose is with Norway, which in Swedish is called *Norrige*, and in Danish, *Norge* (pronounced *Norre*). "In spite of the vague ideas which the ancients entertained of the northern countries of Europe," says Malte-Brun, "it cannot be doubted that the country which Pliny calls Nerigon is Norway. Many geographers[1] have asserted that the name signifies the "Way of the North;"[2] but its true etymology seems to be *Nor-Rige*, "Kingdom of the North," or rather, perhaps, assuming the word Nor as signifying *gulf*, "Kingdom of Gulfs," because in effect its coasts are much more indented than those of Sweden. We thus see that the name of Nerigon has much more analogy with that of Norrige than with that of Norweg, which at the first glance appears to be the origin of the modern name. The early history of Norway is interwoven with the annals of Sweden and Denmark, and consists in legends contained in the Heimskringla or Saga, a collection of ancient manuscripts, which is to Norway what the Edda is to Iceland. The petty sovereigns who held sway in Norway in remote ages were independent, but appear to have acknowledged a kind of supremacy in the kings of Sweden and Denmark, probably more nominal than real; but until the ninth or tenth century little is known of the annals of the country. The Norwegians, of course, constituted no inconsiderable proportion of those daring adventurers who, under the general name of Normans on the Continent, and Danes in Britain, became at one time the terror of all the maritime parts of Europe.[3]

The Royal Northern Antiquarian Society of Copenhagen has published a series of the Saga, comprehending the historical account of events which belong to European history, as well as to that of Scandinavia, during the eleventh and twelfth centuries. It includes a period of about 170 years, beginning with the Saga of St Olaf, the contemporary of Canute the Great of England, who assumed the crown of Norway in 1013, and continuing the series until the death of Magnus Erlingson in a sea-fight with Sverrer I. in 1184. This is one of the most curious and minute pictures of an age long past which the literature of Europe is possessed of. It is not only valuable as an historical document, confirming or adding to our stock of facts relative to a dark period of English history, but as a record of the social condition of the country at that time, and of the influence of the Thing, or assembly of the people; a reference of all matters to this popular convocation being one of the most striking facts recorded in the Saga. From these rude annals we learn that, at a period immediately preceding the first traces of free institutions in our own country, similar institutions existed in great activity amongst these northern people. It seems a fair inference from these facts, therefore, that we owe the political institutions which we enjoy to the Danes and Normans, who were more likely to impose their own peculiar institutions upon those whom they subdued, than to receive institutions from the conquered. History.

From other Sagas preceding that of St Olaf, we learn, that about the middle of the ninth century Halfden the Black divided Norway into five districts, with fixed head places for holding Things in each. At these assemblies laws were framed suitable to the local circumstances of each district, which gave its name to the code. This potentate was succeeded by the celebrated Harold Harfagr, or the Fair-Haired, who ascended the throne at ten years of age, and reigned from 863 to 936. This warlike monarch, after long fighting, reduced all the independent nobles or petty kings to the condition of subjects, and consolidated the various principalities of Norway into one kingdom. Thus was consummated in a single reign, and that, too, in the ninth century, a work which afterwards cost the other nations of Europe several centuries of bloodshed and contention. But this was more easily accomplished in Norway than elsewhere; for in that country the great nobility never had feudal powers, and consequently those who were under them as servants were bound by no such ties of vassalage as the retainers of a Highland chieftain or a Norman baron. They were not taught passive and unconditional submission to a superior, although he might bear the title of king; for before a small sovereign could make war he was under the necessity of assembling the Thing, and obtaining its sanction. The equal division of property among children, which extended to the crown itself, prevented the accumulation of power in the hands of individuals; and the circum-

[1] See the article "Norwege" in the *Dictionnaire Géographique de l'Encyclopédie.* [2] From *Nord* and *weg* (way), Norweg.
[3] See the articles DENMARK, FRANCE, and ENGLAND.

Norway. stance of the total want of fortresses, castles, or strongholds in the country, owing to the division of estates, effectually prevented a nobility from attaining the same power with the nobles of feudal countries, and setting the royal authority at defiance. Some of these nobility or small kings colonized Iceland; and Normandy was conquered by Rolf Gangr, one of those whom Harold Harfagr expelled from Norway. In this king's reign Christianity was introduced into the country, and from this period the events recorded in the historical Saga may claim some degree of confidence.[1] The length of this reign was no doubt favourable to the lower orders, by consolidating their institutions, which, as they weakened the authority of the petty kings, were favoured by Harold. Eric, his son and successor, whom he had associated with himself in the royal authority, was deposed by the Thing on account of his cruelty, and a younger brother succeeded him. Hakon, which was the name of this son of Harfagr, was brought up from his childhood at the court of Athelstane, King of England. He reigned nineteen years, during which period there was frequent reference to the Things, both for amending the laws and for the dissemination of Christianity. It appears that, in attempting to establish the religion of the Cross in his dominions, Hakon had recourse to what were considered as unconstitutional means; for we find that, at a meeting of the Thing, held in the year 956, a husbandman named Asbiorn, of Medalhuus, stood up and declared, on the part of his neighbours and of himself, "that they had elected Hakon to be their king upon the condition that freedom of religion and freedom of conscience should be warranted to every man; and if the king persisted in attempting to suppress their ancient faith, they would elect another king;" adding, "and now, king, make thy choice." This is certainly one of the most striking instances of parliamentary patriotism to be met with in the history of Europe; and we must descend six or seven centuries nearer to the present time before we can match it in the annals of our own country. Hakon was not only compelled to give way, but also to take part in the heathen ceremonies of the meeting. This king was slain in 963, in a battle with the sons of his elder brother Eric, upon whom Athelstane of England had conferred the kingdom of Northumberland.

It appears that, after the death of Harfagr, the small kings again had risen to some degree of power, and that each in his own assembly, called also a Thing, had exercised a limited authority. Olaf the Saint, before he assumed the name of king, consulted one of these assemblies of the nobility as to the way of proposing his claim as heir of Harfagr to the general Things of the people; and he proceeded in such a manner as to show that their voice alone was insufficient to constitute him supreme chief in the land, without the sanction of the general Thing. These institutions appear to have always conferred or confirmed the royal prerogative, and to have been of great importance in that age amongst the whole Scandinavian people. In cases where the good of the community was at stake, they set the royal authority at defiance, and obliged the sovereign to accept of such international contracts as the Things of both countries conceived was for their mutual benefit. The Thing of Sweden compelled the sovereign of that country to conclude a peace with Norway, and to bestow his daughter in marriage on King Olaf, towards whom he cherished implacable enmity. Olaf had the title of Saint conferred on him for the exertions which he made to introduce Christianity amongst his subjects; but in prosecution of this object he exercised the most atrocious cruelties, and completely alienated the affections of his people. He attempted to govern without the intervention of the Things, which became the cause of his ruin; for when Canute the Great, who conquered Norway, invaded his dominions, the people literally "stopped the supplies;" and, unable to collect a force sufficient to oppose the King of England, he was compelled to seek refuge in Russia. For the purpose of recovering his crown, he landed in Sweden with a few followers, and, having received an accession to his force from the king of that country, who was his brother-in-law, marched from the Gulf of Finland across the peninsula to the Fiord or Gulf of Trondhjem. In the meantime the Thing of Norway raised an army of 12,000 bonder, and placed it under the command of Olver of Egge. At the debouche of the valley of Værdal they met Olaf at the head of about 4000 adventurers. The conflict could not be doubtful where there was such an inequality of numbers, and where the superiority lay on the side of those who were fighting in defence of their liberties. King Olaf was defeated and slain, without even showing the prudence and courage which had distinguished his early career. This battle was fought on the 31st of August 1030, and not on the 29th of June or July 1033, as is commonly stated.[2] The body of the fallen monarch was transported to St Clement's church in Trondhjem, which had been erected by himself. In return for the services which he had rendered the church, the clergy soon afterwards canonized him; and even at Constantinople temples were erected to his memory. His tomb was regarded as a consecrated spot, to which pilgrimages were performed, not only by ardent devotees from the north, but also from the south of Europe. Norway.

Canute the Great did not long remain in Norway; and from the period of Olaf's death the country was ruled by native monarchs, who even for a time governed Denmark. It may be gathered from the ancient chronicles before referred to, that at this period society was composed of four distinct orders. The first was the nobility, who were descendants of royal families; and, without regard to priority of birth, those who were descended both on the mother's side and father's side from Harfagr were eligible to the supreme monarchy. They appear to have had no civil power or privilege as nobles, but merely this odelsbaarn-ret to the crown. The odelsbaarnmen, bondermen, or husbandmen, were the proprietors of lands held neither from the king nor from any feudal superior. These were the people who had a voice at the Things. A third order consisted of the unfree men, holding land for services as vassals or as labourers in cottages, but who had no voice in the Things in respect of their land. A fourth order was composed of the trælle or domestic slaves, who were private property, and in a lower state than the former class. This condition of society, which was equivalent to slavery, was abolished by Magnus VII., who reigned from 1319 to 1344.

The most important event in the history of Norway, Sweden, and Denmark, in the middle ages, was the union of the three kingdoms under one sovereign, Margaret, daughter of Waldemar, King of Denmark, which was effected by the league of Calmar, in the year 1397. The circumstances which led to this remarkable occurrence will

[1] Harold Harfagr was born in the year 853; he began to reign in 863, and died in 936. St Olaf's father was Harold Grændske, his grandfather Gudrod, his great-grandfather Biorn Stærke, and his great-great-grandfather Harold Harfagr; and St Olaf was born A.D. 995, only fifty-nine years after the death of his great progenitor Harfagr. A contemporary of St Olaf was therefore a credible source of information for all the events of Harfagr's reign, such as the conquest of Normandy by Rolf Gangr, the colonization of Iceland, &c. (Laing's *Journal of a Residence in Norway.*)

[2] This is put beyond a doubt by a circumstance which all accounts of the battle mention, namely, that a total eclipse of the sun occurred on the same day. Professor Hansteen of Christiania has calculated that such a celestial phenomenon could only have taken place on the 31st of August 1030.

Norway. be found narrated in the article DENMARK. Had this princess been as capable of conquering national prejudices as she was of defeating armies, her dominions would have constituted a great and powerful monarchy. But the passions of her people were more than a match for her policy; and it was no doubt better that the three nations which she governed should each remain in quiet possession of its own freedom, as enjoyed under its own form of government and laws, than that they should lay aside all differences, and, heartily uniting as one kingdom and people, become the terror and scourge of Southern Europe. Margaret died without issue; but during her lifetime she appointed her grand-nephew, whom some historians call her cousin, Eric, a descendant of the dukes of Pomerania, as her successor; and he succeeded to the triple crown of Scandinavia in 1412. The union, however, was far from being cordial; and for rather more than a century local insurrections from time to time broke out and distracted the country. The Swedes, in particular, felt great reluctance to submit to a foreign dynasty; and after various attempts on their part to shake themselves free from the compact of Calmar, the oppression and cruelty of Christian II. led to the final separation of Sweden in 1520, under the celebrated Gustavus Erickson or Vasa. Norway and Denmark, however, remained under one sceptre, till, at the adjustment of European affairs after the fall of Napoleon, Norway was separated from Denmark, and united to the crown of Sweden. This took place in the year 1814.

The circumstances which led to the forcible separation of two countries that had for centuries been united by the closest relations, and the union of one of them with another country which had for as many ages been regarded as a natural enemy, may be shortly stated. The grand object of the leading powers was to induce every state to join in the league against Napoleon; and Sweden, in consideration of an ample bribe, acceded to the general confederacy. One of the foulest stains on the escutcheon of Great Britain is the treaty which she entered into with Sweden, dated 3d March 1813. By this notorious compact against the liberties of a whole people, England gave to the King of Sweden the kingdom of Norway (which was no more hers than Rome or Pekin), together with Guadaloupe, and a million of pounds sterling, as a remuneration to his Swedish Majesty for joining the allied powers against France.[1] After the battle of Leipsic, fought in October 1813, the Crown Prince of Sweden entered Denmark with his army; and after some bloody scenes in Holstein, peace was concluded at Kiel on the 14th of January 1814. By this treaty Denmark gave up all right to Norway, considering it as quite hopeless to enter into a contest with Sweden and England. Although the King of Denmark might relinquish his claim to the sovereignty of Norway, this was no reason for the people of that country making an unconditional surrender of themselves to a foreign potentate. They declared themselves an independent nation, framed a constitution of their own, and proclaimed Prince Christian, son of their former sovereign, and governor of Norway, as their lawful king. Not a little blood was shed in the contention between Sweden and Norway; and England actively interfered by blockading the ports of Norway, for the purpose of starving the inhabitants of the country into subjection. But a speedy settlement of the question became necessary to all parties. The constitution which the Norwegians had prepared in April 1814, and which they were in arms to maintain, was guaranteed to them, upon condition of their accepting along with it the Swedish monarch as king, and the Crown Prince of Denmark abdicating the throne. Matters were arranged on this footing; and on the 17th May 1814, both parties, the King of Sweden and the Norwegian nation, solemnly entered into a compact to the effect stated, under the sanction and guarantee of the allied powers, and of Great Britain amongst the rest.[2] By the treaty the entire independence of Norway as a kingdom was secured, the crowns alone being united, as in the case of Hanover and England. She had a constitution of her own framing, a legislature of her own electing, without being interfered with by any foreign authority in the exercise of her right, and laws of her own making and administering; in short, Norway remained a pure democracy in all but the name. Norway.

Since this union of Norway and Sweden under one sovereign, there have occurred only two events of any importance in the history of the former. The first was the abolition of hereditary nobility by the Storthing; and the second was an attempt of the Swedish cabinet in 1824 to force on the Norwegian people an entire amalgamation of their country with Sweden. But the firmness of the Storthing or Parliament, the honourable feelings of the sovereign, and, it is said, the interference of Russia on the part of the allied powers, prevented such an infamous attempt to violate the faith of treaties, and bring disgrace upon those who had guaranteed them. Great Britain, as a party to the treaty of 1813, and as having inflicted some injury on the country by her ships of war, was especially bound to protect the liberties and national independence of Norway, and to preserve her from becoming a mere province of Sweden, as Poland is now of Russia.

The facts relative to the abolition of hereditary nobility may be shortly stated. It is fixed that the executive power has not a final veto, but only a suspensive negative, till the law is passed by three successive Storthings. In the year 1815 both chambers of the Storthing proposed and passed a motion to abolish nobility for ever in Norway. The slender remains of this class were of foreign, and almost in every instance of recent origin; besides, few of them had enough of property to enable them to hold a dignified station in society. By the law of succession land is equally divided amongst all the children, so that large estates could not be entailed on the possessor of the family title; and hence, to maintain his rank and respectability, a nobleman must have become a placeman or a pensioner, or engaged in operations which would bring nobility into contempt. The existence of a hereditary nobility in a country where the law of primogeniture was unknown in the succession to real property, seemed therefore an anomaly, which, in any circumstances, could not long be tolerated, and which was altogether unsuitable to the state of things which had long obtained in Norway. The royal assent, however, was refused to the proposed enactment in 1815, and again in the year 1818, after it had passed through a second Storthing. To prevent it from passing a third time became the grand object of government; for then it would necessarily have become the law of the land, with or without the royal consent. In 1821, the year when the measure was to be again brought forward, the king in person repaired to Christiania, and used every means to induce the Storthing to abandon it; but in vain. Six thousand soldiers were marched to the neighbourhood of that city, to overawe both the legis-

[1] In the article containing the accession of England to the treaty, after various mutual stipulations, there is a provision containing the following words:—"And his majesty the King of Sweden engages that this union shall take place with every possible regard and consideration for the happiness *and liberty* of the people of Norway."

[2] It is a fact worthy of being recorded, that the committee which drew up this constitution, and laid it before the National Assembly, sat only four days, viz., from the 12th to the 16th of April. That so perfect a model of a free constitution should have been framed in so short a period is truly marvellous; especially as it was not a rough, unfinished outline, but a system of government complete in all its details.

Norway. lature and the people; and extreme irritation prevailed. At this critical moment, when the flames of civil war were about to be kindled, both the Russian and American ministers interfered. What arguments or remonstrances they employed are unknown; but the fact is, that government lowered its tone, the troops were withdrawn, and the Swedish government gave way. The Storthing having passed the measure abolishing hereditary nobility for the third time, it consequently became law. Norway therefore remains a pure democracy, federally united with the monarchy of Sweden. Its constitution has outlived two dangerous attacks upon it; and as the principles upon which it is based have been developed by practice, it has gained additional strength, and been further secured by the love and veneration of the people. The sudden disjunction of Denmark and Norway left, of course, much business to be adjusted between individuals of the two countries. It thus occasioned much distress and loss to persons having connections and property in both; and it still produces a constant intercourse. Few, we believe, will admire the manner in which the union between Sweden and Norway was effected; but as few will doubt the benefits which must result to both from the exchange of mutual hostility for mutual cordiality, and to a certain extent an identity of interests.

Physical aspect. If the reader turn to the map of Europe, he will find that Norway extends from the 58th to the 71st degree of N. Lat., and at the broadest from the 5th to about the 31st degree of E. Long. On the E. it is bounded by Sweden and Russian Lapland, W. by the North Sea, S. by the Skagerrack, and N. by the Arctic Ocean. At the broadest part it is scarcely 300 miles across, and N. of the 63d degree of latitude the breadth is very inconsiderable, the country narrowing to a mere belt. Its shape is peculiar, and, in the main, it resembles that of a Florence flask,—the rounded bottom being presented to the south, and the long narrow neck stretching to the north. Norway thus begins about the parallel where Scotland ends. The most southerly headland in the former, that is the Naes, is nearly in the same parallel as the Pentland Frith, which divides the latter country from the Orkney Islands. The sea-coast presents many features similar to those which characterize Iceland, the north of Scotland, Newfoundland, Nova Scotia, and other islands and continental tracts of country exposed to the storms, the currents, and the perpetual buffetings of the Northern Ocean. The action of the sea alone, however, could not have formed such immense fissures as are found in the solid primary rock on the Norwegian coast. The theory of the elevation of the land by volcanic impulse from below seems alone sufficient to account for such phenomena.[1]

The greater part of Norway may be said to have an outer and an inner coast, the former being a succession of rocky islands of all dimensions, from a mere point to more than a mile in length, and lying within about a mile of the mainland, thus circling all the coast as with a girdle. Boats and small vessels make their coasting voyages within the rocks; for, even when the ocean is strongly agitated, the outer barrier acts as a sort of breakwater, preventing the channel within from being thrown into violent commotion, except where directly open to the sea, when the wind rushes in with great force and agitates the waves.

Fiords. Those immense arms of the sea which penetrate deep into the country are called *fiords* in Norway; a name in geographical nomenclature identifying them with the firths of Scotland, to which they bear a slight resemblance, and also to the maritime lochs so numerous on the west coast of that country; but the nearest approach to similarity, although it falls far short, is an inlet of the sea on the west coast of Ireland known as the Killeries. To enumerate these fiords were only to present a catalogue of names designating the same object in different situations and of different sizes. They vary from 60 to 200 miles in length, and from being several miles to less than a gunshot in breadth; and altogether they constitute one of the most remarkable physical features of the country. In many of these fiords the rocks rise precipitously on either side, and the water is of great depth. The inland streams generally empty themselves into the fiords; and, as in the case of the firths of Forth, Clyde, and others, in Scotland, it is often difficult to say where the river ends and the ocean begins. All along the rock-bound coast these arms of the sea succeed each other with much regularity. In penetrating within their sombre and sometimes dangerous mouths, the scene is all at once changed, presenting at the bottom of these bays, creeks, and other indentations, towns of a pleasant and cheerful aspect, and banks finely wooded with all the varieties of those forest trees which we are accustomed to meet in more temperate latitudes,—such as oak, ash, elder, and elm trees,—and studded with cottages, farmhouses, and country residences, indicating taste and comfort, if not luxury and wealth. The tide rushes into many of those fiords with great violence, especially on the north-westerly quarter of the peninsula. This is readily accounted for from the fact, that the interior basins are often very capacious, whilst the mouths by which the water flows in to fill them are frequently very confined. Opposite to Folden Fiord is the Maelström, or Moskoestrom, long celebrated as the most appalling whirlpool in Europe; but it owes much of its reputation to the exaggerated accounts of travellers. It is situated nearly at the extremity of the range of the Lofoden Islands, beginning between Moskoenæs and Moskoe, and exhausting itself between Varoe and Rost, the last of which is the most westerly of the Lofodens. The whirlpool is simply caused by the rushing of the ocean, as the tide rises and falls, between this chain of islands, which impedes its course like the narrow mouths of the fiords. The relative position of the surrounding islands causes the Maelström to form a large circle; and the great inequalities of its bottom, which, from a few fathoms, deepens suddenly in many parts to 200, increase the violence of the current. A coast like that of Norway, so beset with irregular currents, islands, and rocks, many of the latter close under water, requires at all times to be approached with extreme care, but particularly so in westerly gales, when it becomes a lee-shore. The Norwegian government has recently completed a series of splendid charts, on a scale of 3 inches to the mile (with necessary sailing directions), of the whole coast, from the Christiania Fiord, round the North Cape, to the Russian frontier in the White Sea; a most important and valuable addition to hydrography, of which the lamented Sir Francis Beaufort, our hydrographer of the navy, did not fail to avail himself, and caused fifteen large sheets, together with an index chart, to be published therefrom in 1855, for the benefit of British mariners. Neither are there wanting admirable maps of the interior, prepared by Professor Munch, by Capt. Rosen of the Engineers, and by Capts. Waligorski and Hergoland.

Mountains. The interior of Norway is almost one immense mass of rocky mountains and plateaux. It is mountainous, but it is

[1] Indeed, the large rounded boulder-stones found on the tops of the highest mountains afford evidence sufficient of the fact that at one time Norway had been submerged beneath the Northern Ocean. That the sea never flowed in this quarter of the globe (and consequently in every other), eight thousand feet (the height of the highest mountains) above its present level, may readily be taken for granted. We may, therefore, conclude, that the land has been raised by some mighty power; and we know of none which could effect this but the pent-up fire and compressed gases of a volcano, which, striving for vent, upheaved the solid pavement of the globe which lay above them, and thus broke it up into innumerable fragments.

Norway. so rather by reason of its general elevation than from the conspicuous altitude of its summits. The mountains do not form continuous chains or ridges; neither are they a series of detached elevations; but, especially in the S., they form plateaux or table-lands of great breadth, and generally more or less connected together, though occasionally separated by deep but always narrow valleys. These table-lands are the fjelds of Norway, and are usually distinguished by specific names, as the Dovre Fjeld, Sogne Fjeld, Stagen Fjeld, &c. Their summits are often so level that, did roads exist, a coach and four might be driven along and across them for many miles. The surface of the country may be distinguished into two distinct portions—the comparatively narrow district extending from near Trondhjem to the North Cape, a distance of more than 600 miles, and the more expanded portion, 400 miles in length, from Trondhjem to the Naes of Norway. Throughout the former portion the mountains cling, as it were, to the coast; and though Norway here occupies only one-fourth of the breadth of the peninsula, it contains all the more considerable elevations. They assume here more the form of a connected range than in the southern part of the country, and are known by the name of the Kjölen Mountains. The highest land is the mass called Sulitelma, some of the summits of which rise to the height of more than 6000 feet above the level of the sea. South of Trondhjem (in Lat. 63. N.) the high ground occupies by far the greatest part of the breadth of Norway, and on the parallel of the Dovre Fjeld, fully half the breadth of the peninsula. "By a rude estimation," says Professor Forbes, "on Professor Keilhau's map, I find that the portion of the surface of Norway, S. of the Trondhjem Fiord, which exceeds 3000 feet above the sea, amounts to very nearly 40 per cent. of the whole; and when it is recollected that only one summit exceeds 8000, and that the spaces exceeding 6000 are almost inappreciable on the map, it will be more clearly understood how completely the mountains have the character of table-lands, whose average height probably rather falls short of than exceeds 4000 feet." (Forbes.) The Dovre Fjeld, lying between 62. and 63. of N. Lat., is a table-land of an average height of rather more than 3000 feet above the sea, and having mountains rising, in the case of Sneehœtte, and possibly one or two others, to the height of above 7000 feet. Ymes-Fjeld, the highest summit in Norway, in Lat. 61. 30. N., is estimated at 8400 feet above the level of the sea.

Travellers are proverbially prone to give exaggerated descriptions of the physical features of the countries which they traverse; and from this cause our ideas of the height of some of the Norwegian mountains, and the sublimity of the scenery which they present, have occasionally been pitched rather above the truth, which is the case with respect to the Dovre Fjeld. Mr Laing, in his excellent account of the country, thus describes this great natural feature of Norway:—"The Dovre Fjeld here (at Jerkin, on the northern verge of the range) may be from 24 to 28 miles across. When we give things their real names we take away much of their imagined grandeur. The Dovre Fjeld sounds well, and we fancy it a vast and sublime natural feature. It really is no more than a *fell*, like those of Yorkshire or Cumberland; an elevated tract of ground, whence run waters in opposite directions, and which forms the base of a number of detached hills of moderate elevation. In fact, as a scene impressing the traveller with ideas of vast and lonely grandeur, the tract from the waters of the Tay to those of the Spey, by Dalnacardoch, Dalwhinny, and Pitmain, greatly surpasses it. You are indeed 3000 feet above the level of the sea; but that is not seen; it is a matter of reflection and information. You look down upon nothing below you, and look up only to hills of moderate elevation. Sneehœtte alone comes up to a mountain magnitude: it is 7300 feet above the the sea; but this fell is 3000 feet at this farm-house (at Jerkin), which is about 12 miles from the base of Sneehœtte. The actual height, therefore, of this mountain, for the eye, is about the same as that of Ben Nevis, about 4300 feet, with the disadvantage of gaining its apparent height by a slow rise from the fell. There is a considerable mass of snow in a hollow on the bosom of Sneehœtte, but not more than remains for great part of the summer on hills in Aberdeenshire,—nothing like a glacier. The head and shoulder are clear of snow. The most extraordinary feature of this mountain tract is, that the surface of the fell, and of Sneehœtte to its summit, is covered with, or, more properly, is composed of, rounded masses of gneiss and granite, from the size of a man's head to that of the hull of a ship. These loose rolled masses are covered with soil in some places; in others they are bare, just as they were left by the torrent which must have rounded them and deposited them in this region."[1] Norway

The glaciers of Norway are neither so numerous nor so remarkable, either in beauty or extent, as those in Alpine countries. The Norwegian mountains are, for the most part, continuous table-topped rocks, of an average height of from about 3000 to 6000 feet, intersected with deep fissures, forming the valleys, lakes, rivers, and fiords at their base. On the highest summit of these table-topped mountains the snow lodges, the point of perpetual congelation being between 4000 and 5000 feet above the sea-level. It lies very deep, and in some cases extends in almost one uniform mass for many miles. The largest of these snow-fields is that of Justedalsbraen (sometimes called Sneebraen), and Folgefonden; the latter an extensive plateau of some 30 miles long, by 6 to 18 miles in breadth. Professor Wittich, who ascended the Folgefonden, says, that at most places the snow-field extends to the steep precipices with which the mountainous mass on which it rests terminates on all sides; and that in those places where its edges could be observed, the snow had a thickness of about 40 feet. Glaciers.

Thanks to Professor Forbes, who visited Norway in 1851, we have now been made acquainted with the physical geography of that country, in connection with the snow-fields and glaciers, of which little or nothing was previously known. He describes the Nygaard Glacier, on the Justedalsbraen, as in all probability the most regularly developed glacier in Norway. Like the glaciers of Bondhuus and the Suphelle Glacier, it sweeps down into the very midst of the verdure of the valley. Professor Forbes's observations extended also along the entire coast, up which he proceeded in one of the Norwegian steamboats which every summer thread their way to the North Cape through the numerous islands which lie off the land. The glaciers are not so numerous as might be expected to the northwards, but in some cases they descend very close to the sea, as in the case of those of the Nus Fiord, "the northernmost glaciers on the continent of Europe which descend below the snow-line."

There are a number of lakes in Norway, the largest of which is the Myosen (now traversed by a steam-vessel), a splendid sheet of water, about 60 miles in length, and from 1 to 10 in breadth. Its scenery has been classed with the pastoral or beautiful, rather than with the sublime. Its shores are well cultivated; and with the exception of a few rough promontories dipping into the lake, the slopes are easy, and yield fine crops of oats, bere, flax, pease, and potatoes. Its direction, like that of a great many of the lakes and rivers in Norway, is from N.W. to S.E., crossing the 61st parallel of N. Lat. The depth of the Myosen varies greatly, but it is considered shallower than most of Lakes and rivers.

[1] Laing's *Residence in Norway*, p. 52–3.

Norway. the other Norwegian lakes. The depth in the lower parts is not more than 40 fathoms; often it is much less; but in the upper part it has been found to exceed a hundred. Yet even this is nothing in comparison with the depth of the other lakes, particularly of the Fahmund Soe, which is reputed to be unfathomable; a distinction always allotted to the deepest lake in every mountainous country. A large stream, called the Vormen Elv, issues from the southern limit of Lake Myosen; and at Lillehammer, which is its northern extremity, it forms a communication with Lake Losna by the River Lougen. Into this lake flows a river which rises in the Dovre Fjeld range of mountains, and appears to be the one alluded to by Mr Laing in the following passage:—"The stream which runs through Gulbrandsdal and the Myosen, and reaches the sea at Frederickstad, being the same I left at Lien, comes down from the hills at or near Lessoe, and is there divided into two branches, one of which, as above stated, runs into the Myosen, and the other into the North Sea at the fiord in Romsdal amt, in which the town of Molde is situated; thus including in its delta between four and five degrees of latitude, and all the west and south of Norway. The course of this little river from Lessoe to the sea is very important, as it gives precision to our ideas of the shape and direction of the Dovre Fjeld, and its connection with the Hurunger, the Fille, and the Hardanger Mountains." This river must therefore have a course of probably 100 miles in a north-westerly, and above 250 in a south-easterly direction. It is in several parts of its course of considerable breadth, and at more than 100 miles from its embouchure is described as a large, dark-coloured, and rapid river. A still larger stream is the Glommen, called by way of distinction Stor Elven, or the Great River, from its being the largest in Norway. It rises in the government of Trondhjem, not far from Oresund Lake, through which it runs; and it afterwards traverses the extensive government of Christiania, flowing through Osterdaelen and Hedemarken, passing Kongsvinger, and finally falling into the sea at Frederickstad, after a course, reckoning its sinuosities, of probably more than 400 miles, all in Norway. From the heart of this continent it opens an easy communication with the ocean, and through its means the produce of the interior is brought down to the coast. At about 200 miles from the sea it is described as a fine majestic stream, 200 yards in breadth. Navigation, however, is obstructed by numerous falls, one of which, not far from its mouth, is called the cataract of Sarpen, the roar of which is heard at a great distance. There are other falls on the same river; but the most stupendous natural phenomenon of this description is situated upon the opposite side of the mountain range, on streams which flow into the North Sea. Mr Lloyd[1] (and all subsequent travellers agree with him) describes the falls of Rjukanfos and Voringfos as particularly grand, the first having a perpendicular descent of 450 feet, and the second of 900 feet, the body of water in both cases being very considerable. Mr Forsell, in giving some statistical information regarding Norway, mentions other falls even more stupendous than these. The waterfalls of Norway are, in fact, extremely numerous, and some of them are grand beyond description. "Running water of a bright and sparkling green is seen on every side, at least in the valleys; it pours over cliffs often in a single leap, but more frequently and more effectively in a series of broken falls, spreading laterally as it descends, and riveting the imagination for a long time together in the attempt to trace its subtle ramifications. The sound is rather a murmur than a roar, so divided are the streams, and so numerous the shelves of rock tipped with foam; whilst a luxuriant vegetation of birch and alder overarches the whole, instead of being repelled by the wild tempest of air which accompanies the greater cataract. At other times single threads of snow-white water stretch down a steep of 2000 feet or more, connecting the Fjelde above and the valley below; they look so slender that we wonder at their absolute uniformity and perfect whiteness throughout so great a space, never dissipated in air, never disappearing under *débris*; but on approaching these seeming threads we are astonished at their volume, which is usually such as completely to stop communication from bank to bank." (Forbes.) There are many other lakes and rivers in Norway besides those which we have described, amongst which we may mention the Torris Elv, called the Odderen Elv during part of its upper course, a large stream, which enters the sea at Christiansand; the Topdals, which falls into the sea near the same place; the Louven Elv, which rises in the Hardanger Fjelde, traverses several long, narrow lakes, passes through Köngsberg, and enters the sea near Nauvig, in Lat. 59.; and between this stream and the Lougen, which lies considerably to the N.E., there is more than one large river. A multitude of streams also run into the North Sea. The most important of these is the Namsen (now the favourite resort of our countrymen for salmon-fishing), which, from its exit out of the lakes that give rise to it, has a course of about 90 miles. From the ground sloping with more rapidity upon this side of the mountain chain than on the other, the water-courses must be considerably steeper. Mr Barrow, in his *Excursions in the North of Europe*, speaks in glowing terms of the "snow-capped mountains, the fir-clad hills, the lovely valleys, the clear and limpid streams, the clearer lakes, and unfathomable fiords." The extraordinary clearness of the water has been a subject of remark by all travellers, and has no parallel in any other country; neither has it been satisfactorily accounted for. It may possibly be owing to the purity of the water itself, the clear sky, and clear white sandy bottom which often prevails in the fiords. Sir Arthur De Capell Brocke makes the following observations upon the singular clearness of the water: —"As we passed slowly over the surface (of the fiords), the bottom, which was in general a white sand, was clearly visible, and its minutest objects, when the depth was from 20 to 25 fathoms. During the whole course of the tour I made, nothing appeared to me so extraordinary as the inmost recesses of the deep thus unveiled to the eye."

Norway.

Forests. The forests of Norway, as is well known, are large and numerous; but they do not appear to be so extensive as those of Sweden. In the southern parts of Norway, indeed, and up as far as Trondhjem the supplies of timber are considerable; but to the north of the latter place, and along the sea-coast, as well as on the mountain ranges, wood is not plentiful, many parts of the country being perfectly destitute of it. Norway, however, from the district of Trondhjem southwards, may be considered as a country abundantly supplied with gigantic forests of magnificent trees, amongst which the pine, birch, and aspen are the most celebrated and the most valuable to the inhabitants.

Geology. The prevailing rocks found in Norway belong to the primitive and transition series. The west coast is wholly composed of primitive rocks, gneiss and mica-slate greatly predominating. Secondary rocks occur but rarely, and alluvial deposits are not so abundant as in many other less extensive regions. Granite is rare. When it appears, it is frequently in veins traversing the primitive stratified rocks, or running parallel with beds or strata; and sometimes it is found spread over the surface of mica-slate, as at Forvig; or irregularly associated with clay-slate and diallage rock, as in the island of Mageroe. But by far the most abundant rock in Norway is gneiss, all the others of the primitive

[1] *Field Sports of the North of Europe*, vol ii., p. 295.

Norway. series appearing to be subordinate to it. Extensive tracts of country, and long mountain ranges, seem to consist almost entirely of gneiss. In some parts it abounds in veins of rose and milk quartz, in iron ores, in garnets (sometimes the precious, but most frequently the common garnet), and other minerals. Mica-slate, however, which rests upon and alternates with the gneiss, is far from being so generally distributed; as is also the case with the clay-slate. In some places steatite occurs in beds, and is quarried in slabs to be used for different purposes. Quartz rock, various hornblende rocks, and limestone occur in beds subordinate to the gneiss and mica-slate. One side of the valley of Shalheim, situated between Bergen and Sognefiord, is bounded by hills of snow-white quartz, which are almost bare, and present mural precipices having a very singular appearance at a distance, from their shining white colour. Gabbro or diallage rock occurs in great quantities, connected with clay-slate, in the island of Mageroe and in other parts of Norway. The class of transition rocks contains, besides graywacke, alum, slate, limestone (sometimes combined with tremolite), and other rocks well known to mineralogists as belonging to the following eruptive series:—Granite, which sometimes contains hornblende; syenite, which contains a beautiful labradorite, and often crystals of the gem named zircon; porphyry, and associated with it various trap rocks allied to basalt and amygdaloid. All the mountains, and especially those of the south, contain a great number of minerals much prized in collections, and of metals valuable to man, amongst which may be mentioned gold, silver, iron, copper, cobalt, and lead. The mines of silver in Norway are situated at Köngsberg; but although they once afforded rich returns, they now scarcely repay the labour bestowed on them. Large masses of native silver have been found here; one of them, about 6 feet long by 10 inches in diameter, is now in the museum of Copenhagen, weighing upwards of 500 lb. The Köngsberg mines abound with mineralogical curiosities, of which the most remarkable is native electrum, a natural alloy of gold and silver. There is a gold mine at Edswold, in the district of Rommarge, and mines of lead and silver in that of Jarlsberg; but they have not been wrought to any extent. The copper mines of Norway are chiefly situated in the northern division of the kingdom. The most considerable are those at Alten, situated in the 70th parallel of latitude, and worked by a company of Englishmen; and at Röraas, on the Swedish frontier, in Lat. 62. 35. N.; the latter of which were discovered in 1644. These consist of three mines, called the Storvuitz, Röraas, and Ejda. The ore both of the Alten and Röraas copper mines is of the same character; the veins not rich, but numerous and powerful. Copper is supposed to exist to the northward of Röraas, in various parts of the mountain range which divides Sweden from Norway. The other copper mines are from 15 to 20 leagues from Trondhjem, at Quikne, Laeken, Selboe, and in the district of Christiania at Fredericksgave or Foledel. The principal iron mines are situated in Southern Norway; and of these the most distinguished are those of Arundal and Krageroe. The mines of Arundal are celebrated for the richness of their mineralogical treasures. Many of these are rare, such as botryolite, datholite, wernerite, scapolite, and moroxite; besides abundance of epidote, actinolite, cocolite, and colophonite. The ore (magnetic iron ore) is found in beds of gneiss, of which the country is chiefly formed. The total quantity of iron ore obtained annually does not exceed 30,000 tons, but it is of the finest quality. The total produce of copper varies from 400 to 500 tons. The mines of cobalt, which are worked at Modum and Fossum, are extensive, but not very deep. There is a mine of plumbago and black lead at Engledal. The mines of alum, which are worked in the mountains of Egeberg, near to Christiania, afford not only a sufficiency for the consumption of the country, but some for exportation. Norway possesses quarries of granite, marble, millstone, whetstone, slate, and clay. Granite is exported to Holland, and marble and other minerals to Denmark. Norway.

Some valleys in Norway give abundant indications of their having been lakes of fresh water, which were either gradually drained as the land became elevated, or, bursting the barriers that confined them, suddenly laid their basins dry. Mr Laing describes one of these in the following passage:—"On ascending the steeps which bound the flat alluvial bottom of the valley on each side, and which consists generally of banks of gravelly soil, one is surprised to find a kind of upper terrace of excellent land, cultivated and inhabited like the bottom, and consisting of the same soil, a friable loam. This terrace rests against the primary rocks of the fjelde, which are here limestone, marble, and gneiss, or rock of the micaceous family, of which the laminæ are singularly twisted and contorted; and the terrace has evidently been the bottom of an ancient lake, which has been bounded by these fjelde ridges." The same traveller gives an account of one of those ancient sea-beaches, which, in other countries besides Norway, are calculated to arrest the attention and excite the wonder of the observer of nature. He is speaking of the Snaasen Vand, a lake some 60 or 70 miles, north from Trondhjem. "About 7 miles inland from the present sea-strand, at the head of the fiord, and about 60 feet above the present high-water level, there is an ancient sea-beach of a very remarkable character. About the house of Fossum, and 40 feet higher than the lake of that name, the sea-shells are so abundant that they might be applied to agricultural purposes, and they lie close to the surface." At another place in the neighbourhood there is a large bed of shells, which have been used in mending the road for a considerable distance towards Snaasen Vand. "They are entire; the upper and under ones of the mussel, cockle, and clam are united, and the mussels grouped together, as in the living state; so that this bed has clearly been the spot upon which the animals lived." From these and other indications, it is concluded that a shore, in a direction nearly parallel to that of the present one of the Trondhjem Gulf, and on a level at least 60 feet higher, has existed at a recent geological period. These beds are not covered with any thickness of decayed vegetable soil, and the shells retain in part their natural hue and enamel. The land, therefore, has been elevated at no very distant period; at what rate per century has not been determined as to this side; but the Swedish philosophers assert that the change of level in the Gulf of Finland is at the rate of 4½ feet in a hundred years. Such could not have been the case on the shores of Norway washed by the North Sea, for the relative positions of known points upon the line of the seashore, to the present level of the sea, are by historical evidence ascertained to have changed little if any during a thousand years. The change of level may have been local, or it may have gone on more rapidly at one time than at another. Ancient lakes, &c.

Earthquakes have been repeatedly experienced in Norway. History records one which occurred at Trondhjem on the 18th of July 1686, and another on the 1st of April 1692. On the 14th of September 1344, the River Guul disappeared in the earth; and on its bursting out again destroyed forty-eight farms and 250 human beings. About the same time a great earthquake took place in Iceland. Indeed the whole aspect of this country bears evidence to the fact, that at some period, or more probably at different periods, its surface has been elevated, depressed, and shattered by great convulsions.

From the general elevation of the land, the climate is of course rendered more severe than would naturally be- Climate and soil.

Norway. long to a country under the same parallel, the general elevation of which was more nearly on a level with the ocean. The winters are long and very cold; but, as in all northern climates, their length and severity are in some measure compensated by the great heat, and consequently rapid vegetation, in summer. Towards the east, and in the interior, the winter is longest, the cold, generally speaking, always increasing towards the north. The effects of the sea-breezes upon the general temperature of the coasts of all countries are well known. Winter, however, is very pleasant and salubrious; for although the air is cold, it is dry and bracing, not damp and raw. But the western part, especially about Bergen and along the coast, is proverbially rainy, owing probably to the high mountains, which attract the clouds wafted from the ocean. But the country behind this barrier is on that account particularly dry, perhaps somewhat too much so. In Norway the weather is in general more steady than in Britain; it is either good or bad for considerable periods. The summer season is delightful, and very warm. In narrow glens it is too hot during the middle of the day; but the morning, evening, and midnight hours are charming, and peculiar to this country. The sun is below the horizon for so short a time that the sky retains the glow, and the air the warmth and dryness, which are as grateful to the eye as they are pleasing to the feelings. A little north of Trondhjem it continues above the horizon for the twenty-four hours in the height of summer. Summer lingers long in this country; and, in general, it is an unbroken series of beautiful days. The disagreeable season is the spring (April and May), when, in the transition from winter to summer, the snows are suddenly melted, and the ground is rendered uncomfortable for travelling. Damage is sometimes done in this season by the rapid swelling of the torrents and rivers. When the white covering of winter disappears, vegetation bursts forth at once, and advances with astonishing rapidity.

The mean annual temperature at Christiania is 41°·5, the winter being 23°·2, the summer 59°·8. At Bergen the mean annual temperature is above 5° higher than at Christiania, being 46°·8; and while in the summer months the temperature is nearly the same, the winter months at Bergen are, on an average, not less than 13° warmer. At Trondhjem, in Lat. 63. 26. N., the mean annual temperature for the year 1826–7 was 40°·8, being in each month as follows:—November, 33°·1; December, 31°·3; January, 18°·5; February, 16°·7; March, 27°·5; April, 42°·3; May, 56°·3; June, 62°·4; July, 57°·9; August, 54°·7; September, 51°·1; October, 38°·7. At Alten, in Lat. 69. 57., the average temperature for eleven years (1837–1848) was at 9 A.M. 34°·50, and 9 P.M. 32°·83; mean, 33°·66. The mean temperature of February, which is decidedly the coldest month, is 15°·4; and of August, which is usually the hottest, 54°·3. This range, however, is small compared with the actual extremes on particular days; for we find in 1848 the maximum at 86°·9, the minimum at −20°·2. It is rarely, however, that the mercury falls below zero; whilst there is not perhaps another part of the earth's surface on this parallel where the mercury does not freeze in winter. The fall of rain and snow here in 1848 was 17·19 inches. The gulf-stream exercises an important influence upon the climate of Norway. Taking its rise in the Gulf of Florida, it proceeds northwards and eastwards, until it breaks on the shores of Europe and Northern Africa, a portion of it striking the western coasts of the British Isles, and being prolonged to the coast of Norway, imparting warmth to water and to land, and effectually repelling the invasion of floating ice, with which the coast of Norway would otherwise be continually menaced. It is a remarkable fact, that the smallest piece of drift ice is unknown on any part of the Norwegian coast, though it extends to Lat. 71. N.; while off the coast of North America they are occasionally seen as far south as Lat. 41. N. Norway.

The luxuriance of vegetation being abridged by the length and severity of the winter, the soil is thus indirectly rendered comparatively sterile. In America the immense forests are continually enriching the mould with their decaying foliage; but in Norway the paucity of alluvial tracts, the prevalence of rock, seldom far beneath, and often forming the surface, together with the want of vegetable decomposition, materially detract from the quantity as well as the quality of the soil. In some parts it is very rich; and the valleys, in particular, are celebrated for their luxuriant fertility. But much of the soil is thin, and obstructed by rocky knobs rising above its surface, and interfering with the labours of the husbandman. "I have not, indeed," says Mr Laing, "seen in Norway twenty acres of arable land in one field, without some obstruction from knobs of stone." The vegetation of the west coast of Norway is very similar to that of Britain, but in the south and east there is found a completely different flora, approximating to that of Denmark and Germany. The cause of the remarkable difference between the flora, and also the fauna, of the two coasts, may probably in part be referred to the absence of tides on the south coast. This circumstance seems to exercise an important influence on the character of the natural productions of the country; and we the more especially refer to it, as it seems to have been hitherto entirely overlooked by naturalists. At Bergen the tide falls 6 or 8 feet, but on the south coast it does not fall 6 inches.

Natural productions.

"In Norway," says Mr Laing, "the trees of the pine tribe are called *furu* and *gran*. Furu is our pine (*Pinus silvestris*), and gran is our fir (*Pinus abies*); the one is the red wood, and the other the white wood of our carpenters. There are whole districts which produce only furu, others only gran; and this seems not exactly regulated by latitude or elevation. The zones at which different trees cease to grow appear to be a theory to which the exceptions are as numerous as the examples. In Romsdal amt, at Fanne Fiord, near Molde, in Lat. 62. 47. N., and with a medium temperature of only 4° of Reaumur (41° of Fahrenheit), pears, the bergamot, gravenstein, and imperial, and also plums, come to perfection; and the walnut tree often bears ripe fruit. Hazel and elm in the same amt form continuous woods, as at Egerdal. Yet the gran disappears altogether, although in the same degree of latitude it grows at an elevation of 1000 feet above the sea in the interior of Norway, and even in Lat. 69. in Lapmark. It has been found a vain attempt to raise it in Romsdal amt, a locality in which the following trees and bushes grow readily:—Canadian poplar, balsam poplar, horse chestnut, larch, elder, yew, roses of various sorts, lavender, box, laburnum, white thorn, and ivy. Larch brought from Scotland appears to thrive. There must be something in the nature of the plants, not connected with elevation or latitude, that determines the growth of the gran and furu." Wood grows in sheltered situations in Nordland and Finmark, as far north as Alten Fiord (Lat. 70.), but of diminutive size, and in limited quantity. Trees in the valley of the Namsen are large enough for building material and the masts of ships. Laing remarks, that he "did not expect certainly to be charmed with the crops in the sixty-fifth degree of north latitude; but the vegetative power, whatever be the cause, is more vigorous here than in the north of Scotland. Some of the largest establishments of saw-mills in Norway are supplied with trees from the forests around the Snaasen Vand. Of ordinary productions,—as rye, oats, bere, flax, hops,—there appeared to be great crops. This may well be in a soil and climate which raises such noble forests. Behind the house I inhabited is a standard cherry-tree bearing ripe fruit. It would be a rarity in Scotland to raise

Norway. them unless against a wall, even eight degrees of latitude south of this." Here Mr Laing found hops cultivated as a crop, while flax ripened so as to be fit for seed. The mountain and common ash are here scarce; the aspen, wild cherry, birch, and the pine tribes, being the trees, and the juniper, wild raspberry, and wild rose, the bushes which generally prevail.

The country south of the Namsen may be considered as capable of producing, in favourable situations, the grains and fruits of England, and these, too, often in the highest degree of perfection. Most kinds of fruit are abundant, but the greatest favourite is the cherry. The crop of cherries is scarcely ever known to fail; and in proof of the abundance of this fruit, it may be mentioned that the Norwegians preserve it in great quantities, and use it in many culinary operations. Amongst the fruits growing wild are strawberries, raspberries, cloudberries, cranberries, and various other kinds of berries. The three first mentioned are considered as delicious, and they are eaten both when freshly gathered, like cultivated strawberries, and after being preserved.

Zoology. The animal kingdom of Norway requires some notice. As population has increased, the wild animals have of course gradually disappeared, and the bear and the wolf are no longer the terror of the traveller, as they were wont to be. In November the bear retires to some sheltered hole in the rocks of the Fjeld, and remains in a state of inactivity, without food, it is said, until April. Indeed many of the smaller animals—the field-mice, the lemmings, and, Mr Laing conjectures, many of the birds—pass the winter in this climate in a state of occasional torpidity. The wolves are not so dangerous animals as those of the south of Europe. They rarely attack a man, but they will carry off a dog at his side; and they often commit serious havoc amongst the domestic animals. The loss of sheep, calves, cows, and foals, in certain parishes, during the season when they are at pasture, is sometimes immense. Bears also commit depredations of the same kind, but not nearly to the same extent as the wolf, which, when he gets into a herd, bites and tears all that he can overtake. Many horses may be seen scarred by them. The elk is now rarely met with, and in all likelihood has entirely disappeared from this part of Europe. It is described in former times as a magnificent animal, being often seventeen hands in height, and sometimes exceeding in size the largest horse. The glutton or wolverine, so called in America, is reckoned a Norwegian animal. Its total length is not more than two feet and a half, and it flies from the face of man. It feeds chiefly upon beasts which have been accidentally killed; but it will hunt small animals, such as meadow-mice, marmots, and the like, and occasionally attack disabled animals of a larger size. Although not fleet, it is very industrious, and does great injury to the small fur trade in the northern parts of Europe. The rein-deer, which is found in considerable numbers on the Hardanger Fjeld and the Sogne Fjeld, and the diversified qualities of which are so beautifully adapted to the bleak and inhospitable regions in the north of Norway, will be found described in the article LAPLAND. The author of *Notes on a Yacht Voyage to Hardanger Fiord* mentions falling in with a herd of from three to four hundred rein-deer when descending from the Folgefonden. "The whole herd was soon out of sight. In the distance it resembled a vast moving cloud against the snow, with a small dark mote in front. The guide said they were not often seen congregated in such large numbers." The beaver, although not extinct, is rare, and lives solitary, not, like the American beaver, in society. A particular kind of dog, with a remarkably fine, soft, and glossy fur, is bred for its skin, which is made into pelisses for winter wear. Besides the wild and tame rein-deer, red deer are pretty numerous in some districts. The fox and the lemming are abundant in some parts, particularly in the north. A multitude of birds inhabit the coasts of the ocean, and Norway furnishes a considerable part of the eider-down, so well known to the luxurious in couches. Game is plentiful; the principal birds being called the tydder, roer, ryper, and jerper. The tydder is the bird known of old in Scotland by the name of capercailzie, and which became extinct in that country, but has been introduced again of late years by the Marquis of Breadalbane and other noblemen. The cock is a noble bird, of the size of a turkey-cock, with a bill and claws of great strength. The roer is the female, and in size, plumage, and appearance so different from the male, that it has received a different name in the language. The ryper is the same as the Scottish ptarmigan, but larger and better clothed. Its flavour, however, is inferior to the game of the Scottish hills. But the jerper is a more delicate bird for the table than any of our game. It is of the grouse species, and about the size of a full-grown pigeon. The silence of the forest solitudes is occasionally broken by the sweep of the eagle's or the heron's wing; but the traveller in Norway is generally struck with the limited number of small birds which he meets in the course of his ramblings. Magpies, the Royston crow, and swallows, are common; but the lark, linnet, thrush, blackbird, robin, and some others common to Great Britain, are little known here. Mr Barrow mentions hearing the cuckoo, not far from Röraas, at an elevation of 3000 feet above the level of the sea. Hares and squirrels are in considerable abundance; and there are some other quadrupeds and birds no strangers in the country, but they are of too little importance to require any particular mention. Amongst domestic animals may be mentioned the horse, goat, sheep, and cow; the goose, the duck, and the turkey, which are also found wild. Of horses there is a small breed very general in Norway, and another of a larger size, which is much esteemed for its swiftness and sureness of foot. "These Norwegian horse are beyond all praise," says Mr Laing: "they scamper down hills as steep as a house roof, and in going up hill actually scramble. They have no objection whatever, if you have none, to any path or any pace; they are the bravest of horse kind." All travellers speak of them in similar terms. They are fed entirely upon hay, which, although merely withered grass, appears to be more substantial than ours, from the wind and powers of the horses, which live upon nothing else. The sheep are shaped like deer, having long legs and small muzzles. Numbers of goats and cows are kept, the milk which they yield being very rich and highly esteemed. Fish abound in the seas, lakes, and rivers of Norway; and the inhabitants not only derive a considerable portion of their subsistence from fishing, but it also forms an important article of export. Salmon-fishing in Norway has become a favourite pastime with many of our countrymen. Amongst the insects, the gnat, or rather mosquito, is found exceedingly annoying. They are in greatest abundance and most venomous in the north. The *Furia infernalis*, so called from the dreadful effects which follow from its bite, frequents the marshes or boggy grounds. The acute pain and inflammatory swelling which its bite produces are removed by a curd poultice, which is said to be an infallible cure. The entomology of the south of Norway is very similar to that of the south of England, whilst that of the west resembles the entomology of Scotland.

Norway.

Agricultural products.

The principal products of the Norwegian farm are,—oats, rye, wheat, bere, hops, flax, a kind of bearded spring grain, with potatoes; and a large portion of every farm is set apart to grow grass for the cattle and horses. The grass for the most part is natural, sown grasses for hay being very little cultivated. The land, after a bere crop following potatoes, is left to sward itself with natural grasses for four years, and to form the hay land; so that the proportion of grass to

Norway. arable land is much greater than in our farms. The natural grasses do not attain any length, and they are shaven as close to the ground as a bowling-green. The fields are not what is called top-dressed, as with us. The scythe in use is much shorter in the blade than that of Great Britain, and it answers the purpose much better. Potatoes have been much cultivated since 1812 and 1814, when bad crops, and the war then raging, reduced many to the use of bark-bread. A small inclosure for hops is attached to every farm-house; but garden vegetables are little used. Probably the short interval between winter and summer allows little time for attending to any but the essential crops. The hop flourishes with little attention under the sixty-fourth parallel; a striking fact, seeing that this plant is delicate and precarious in the south of England. In farming operations, ditching, draining, and clearing land of vegetable and other obstructions, are prosecuted with great spirit and success. Agriculturists are continually adding to the quantity of arable land in the country by thus redeeming the soil from its original wild state. However, from causes already mentioned, Norway is not capable of furnishing the means of subsistence to any considerable population. Generally speaking, only the glens of the country are inhabited. On the dividing ridges there is little or no cultivation, and, indeed, no soil to cultivate, but only rounded masses of gneiss and micaceous rocks, with juniper, fir, aspen, birch, and beech, growing where they can amongst the stones.

Mr Laing gives a minute account of a Norwegian farm rented by a Scotchman; and as he considers it "fitted to be the representative of a large portion of the estates into which this country is divided," we shall abridge his description. Each farm may be considered as consisting of three divisions. The first is the infield, or what we should call the mains, or home acres, inclosed for the crops and the best hay. The next is the mark or outfield, also inclosed, and affording the out-pasture for the cattle. Parts of it are occasionally fenced off, and broken up for grain, and, when exhausted, are left to sward themselves; so that when the cattle are sent to the fjelde in summer, some hay is got from the mark. There is often a still rougher piece of ground divided from the mark, as a range for goats and young cattle, called the out-mark. The third division is the seater. This is a pasture or grass farm, often at the distance of 30 or 40 miles up in the fjelde, to which the whole of the cattle and dairymaids are sent for three or four months in summer. The huts on these seaters are substantial buildings, with every accommodation necessary for the dairy, and butter and cheese are accordingly made in very considerable quantities. "The farm of my countryman," says Mr Laing, "consists of 1276 mælings, or 290 English acres; but this does not include the seater, which happens here to be on the hills immediately behind the farm, is covered with fine trees, and is of a defined boundary, extending about a Norwegian mile (7 English miles) in circuit. On the measured land, 148 acres are cleared; but, being farmed in the Norwegian style, one-third only bears crops of corn and potatoes. The remainder is always in grass or hay, for the winter support of the cattle. It is natural grass, not top-dressed with manure, and is mown when not above the length of one's finger, so that the proportion of arable land that must be given up to keep the cattle in winter is enormous. It is the system of farming in this quarter; 142 acres outside of the 148 infield are half cleared, being fenced off and ploughed in patches. It bears good grass, but is encumbered in some places with brushwood and stones."

"This farm supports twenty cows, seven horses, and a score or two of sheep and goats. The accommodation for cattle is excellent. They stand in a single row in the middle of a wide house, with partitions between each, and room before and behind greater than is occupied by the animal itself. The cow-house is lighted by glass-windows on each side. The cattle stand on a wooden floor, below which is a vault, into which the dung is swept by a grated opening at the end of each stall." All the cow-houses in Norway are constructed on this large and convenient scale; and neither cows nor horses require litter, which is a great saving of fodder. Besides, they are kept perfectly clean with comparatively little trouble. The value of a farm in Norway depends very much upon the locality. In Forester's *Norway* (Appendix), one containing about 300 acres of cultivated land, besides some bogs capable of cultivation, and a good little forest of different kinds of wood, is mentioned as having cost about 12,000 dollars, or about L.2200 sterling. Twenty years were allowed to discharge the purchase-money, the tenant in the meantime paying a rent of L.4 per cent. Many farms, however, of like extent, may be had for one-half, or even one-third of this sum. The one mentioned by Laing was considered worth about 4000 dollars. Norway.

"The harvest-work here," says Mr Laing, "and I believe all over Norway, is well done; and parts of their management might be adopted with advantage in our late districts, where so much grain is lost or damaged almost every autumn by wind or rain. For every ten sheaves, a pole of light strong wood, about the thickness of the handle of a garden-rake, and about 9 feet in length, is fixed in the ground by an iron-shod borer; it costs here almost nothing. A man sets two sheaves on the ground against the stem, and impales all the rest upon the pole, one above the other, with the heads hanging downwards." This is certainly a mode very superior to ours; and they have likewise a better way of cutting it, by which little of the grain is lost. But for an account of this process, and other farming operations, we must refer to Mr Laing's work (pp. 96, 106).

The breed of cattle in Norway is fine-boned, thin-skinned, and kindly-looking; the colour is generally white, sometimes mixed with red, but seldom entirely black. The head and muzzle are as fine as in our Devonshire breed. There is so little coarseness about the head or neck of the bull, that the difference between him and the ox is less observable than in our breeds. The cattle are all very carefully attended to, and form an important branch of the husbandry, as dairy produce enters much into the food of every family, and is more certain in this climate than that of grain. The cows, sheep, and goats are more tame and docile than they are in Britain, from the constant care and attendance bestowed on them during the long period which they must stand within doors; and the Norwegians are remarkably kind to their domestic animals. Goats are a favourite stock, and on every farm appear to be much more numerous than sheep. The goat will eat and thrive on the shoots of the dwarf birch, beech, and young fir; but the sheep will not, and in winter it requires some hay. The goat then gets dried leaves and shoots of the beech, which only cost the trouble of collecting and drying them.

Irrigation is carried on in many parts to an extent quite unknown in this country. Hay being the principal winter support of live stock, and both it and corn, as well as potatoes, being liable, from the shallow soil and powerful reflection of the sun's rays from the rocks, to be burned and withered up, the greatest exertions are made to bring water from the head of each glen, along such a level as will give the command of it to each farmer at the head of his fields. This is done by conducting water in troughs made of the half of a tree roughly scooped out, from the highest perennial stream amongst the hills, through woods, across ravines, along the rocky and often perpendicular sides of the glens; and from this main trough lateral branches shoot off to each farm. The farmer distributes this supply by moveable troughs amongst his fields, watering each rig successively. The quantity of land traversed by these artificial water-courses is very great.

In winter, when agricultural operations are suspended, the Norwegian employs himself in making all the implements, furniture, and clothing, which his family may require; thrashing out the crop, attending to the cattle, driving about to fairs, or paying visits. The heaviest of his occupations is driving wood out of the forests, or bog-hay from the fjeld where it is made in summer by those who attend the cattle. The distillation of potato-brandy was, until very lately, general all over Norway, every common bonde or peasant proprietor distilling his own few barrels. The vice of drunkenness, however, had become so flagrant, that it was considered necessary by the Storthing to place very stringent restrictions on the sale and manufacture of spirits; and now private stills are strictly forbidden, and spirits are only allowed to be sold in the towns. The improvement in public morals, in consequence, has been very marked. In the valley of the Miosen Mr Brace made inquiries as to the general morality of the bonders of the province, and learned that intoxication was certainly very much diminished since government had made it so difficult to get brandy, and that altogether there was a great progress; which doubtless is the case in all other districts.

The thrashing machines in general use amongst agriculturists are similar in construction to those of Scotland; and some have grinding machinery attached to them. There is an institution of a very peculiar nature, which is quite common all over Norway. In this country there are no merchants equivalent to our corn-dealers, nor are there any weekly markets held for the sale of grain. There are no middle-men between the grower and the consumer, and any surplus grain which the farmer may have is stored up in what may be called corn magazines, which are just large warehouses erected in various parts of the country, as the necessities of the inhabitants require them. What grain the farmer thinks he will not require he conveys in sledges to these places, and for every eight bushels which he deposits, he receives nine at the end of twelve months; in short, he lays it out at interest, and has an increase of one-eighth per annum. If, however, he has none deposited, or overdraws, he pays for the quantity received in loan at the rate of one-fourth of increase per annum; so that for every eight bushels which he takes he pays back ten at the end of twelve months, or at that rate for whatever time he may have the loan. This is, in fact, a savings-bank for corn, and is probably the most ancient of these institutions. The small profit which occurs upon these transactions defrays the necessary expenses of building and keeping up the magazines, which are entirely under the management of the bonder or peasant proprietors. In Norway the bulk of the farmers have no rent to pay, the property being their own; the articles which their farms produce constitute nearly the whole of the food or raiment which they and their people require; and there are not, as in other countries, considerable masses of population in towns and villages, who, not being producers of food themselves, must obtain it from those who are; so that the farmer is less dependent upon money-bringing crops than is the case with us. If he raise what is sufficient for his own household consumption, with a little surplus for sale to purchase a few luxuries, all the purposes of farming are served with him.

State of property.

Property in Norway is held by what is called the udal or odel system of rights, not from any superior, not even from the king, but, as the possessors proudly express it, by the same right by which the crown itself is held; consequently there is no acknowledgment, real or nominal, as feu-duty or reddendo, paid. In this country all lands are theoretically said to be held from the king; and, according to Sir Edward Coke, we have no allodial lands. In Norway estates are allodial, the absolute property of the owner; they are therefore possessed without charter, and are subject to none of the burdens and casualties affecting land held by feudal tenure direct from the sovereign, or from his superior vassal. There is, in short, a total negation of the feudal principle; there is neither superior nor vassal; so that the military service which the latter paid to the former in consideration of the land which was granted appears never to have existed in Norway; and as this constituted the foundation of the law of primogeniture, so where such service was entirely unknown, there was no necessity for that law, which consequently remained equally unknown. In all feudal countries the eldest male heir has to pay an acknowledgment to the feudal superior on his entering as vassal in the land. But udal, or noble land, as the word signifies, not being held for military service to a superior, no *delectus personæ* as to who should inherit it was competent to any authority, and consequently no preference of the eldest male heir could grow into the law of succession to land. Hence the land came to be equally divided amongst all the surviving children, male and female. There appears, however, to be a species of entail connected with the udal tenure. If the udalman in possession should alienate to a stranger, the next of kin has a right of redemption on paying the price of the land. This is called the Odelbaarn's Ret, and all the kindred of the udalman in possession are what is called Odelsbaarn to his land, or, in other words, have a certain right in the order of consanguinity. By recent enactments, this right of redemption has been limited in its exercise to a period of five years; and it is provided that all improvements, as well as the original price, must be paid for.

The equal partition of property amongst children by the udal tenure has prevented the accumulation of property in large masses; but, as might have been expected by theorists, it has not led to subdivisions of estates to an injurious extent. "The division of the land appears not," says Mr Laing, "during the thousand years it has been in operation, to have had the effect of reducing the landed properties to the minimum size that will barely support human existence. I have counted from five-and-twenty to forty cows upon farms, and that in a country in which the farmer must, for at least seven months in the year, have winter-houses and provender provided for all the cattle. It is evident that some cause or other, operating on aggregation of landed property, counteracts the dividing effects of partition among children." In another place Mr Laing says, "The estates of individuals are generally small; and the houses, furniture, food, comfort, ways and means of living among all classes, appear to me to approach more nearly to an equality to one standard than in any country in Europe. This standard is far removed from any want or discomfort on the one hand, or any luxury or display on the other. The actual partition of the land itself seems, in practice, not to go below such a portion of land as will support a family comfortably, according to the habits and notions of the country; and it is indeed evident that a piece of ground without houses upon it, and too small to keep a family according to the national estimation of what is requisite, would be of no value as a separate property. The heirs accordingly either sell to each other, or sell the whole to a stranger, and divide the proceeds. The duty of the Sorenskriver, or district judge, consists chiefly in arranging this kind of chancery business, and all debts and deeds affecting property are registered with him."

The cause which, according to Mr Laing, has prevented excessive subdivision is, "that in a country where land is held, not in tenantry merely, as in Ireland, but in full ownership, its aggregation by the deaths of co-heirs and by the marriages of female heirs among the body of landowners, will balance its subdivision by the equal succession of children." This is undoubtedly true; and when taken in connection with other facts, may sufficiently explain the case. Mr Laing informs us that the standard of living is

Norway. high in Norway; or that the population is much better clothed, lodged, fed, and generally provided for, than our labouring and middling classes in the south of Scotland. The dwelling-houses of the meanest labourers are divided into several apartments, and have wooden floors and a sufficient number of good windows, with some kind of outhouse for cattle and lumber. Their food and clothing are equally good and substantial. Now it seems quite clear that a people habituated to such a standard of subsistence and comfort will not only not suffer their condition to sink indefinitely below it, but by prudence and foresight in the contraction of marriage and the raising of a family, will keep down their numbers considerably within their means of subsistence. In Norway, that condition which secures respectability to a common man is one in which he commands not only all the comforts, but most of the luxuries of life common to the country; and the natural desire of all mankind to keep up caste, to maintain themselves in that station in which they were born, not to decline from it, and fall, as it were, out of the ranks, will operate as a most powerful check upon the minute subdivision of land. There are other causes in operation, to which our circumscribed limits will only admit of our adverting. These are the ancient and confirmed habits of the people, which may be taken into account as a corollary of the preceding proposition; and the absence of impediments, such as fines or alienation, or imposts of any kind, in the way of sale or conveyance. Where such fines exist, the difficulties of re-uniting land which has been subdivided are great and annoying.

The bulk of the population in Norway consists of two classes of landholders: those who have farms larger than they themselves can cultivate, and those who exclusively farm their own estates. The first are called proprietors, a sort of conventional term, equivalent to our esquire; the smaller landholders, who work upon their own estates, are called *bonder*, a term, as appears, nearly equivalent to feuar in Scotland. The incomes of the former seldom exceed L.150 or L.200, although there are some who possess as much as L.3000 or L.4000 sterling per annum. The Norwegian valleys are crowded with bonder farms, which are very numerous throughout the country, and, with their look of plenty and completeness, may compete with the richest and most beautiful in Scotland. Mr Laing draws a very pleasing and interesting picture of this class of people, whose comfort and happiness may indeed be inferred from a short statement of facts. They are owners of their own little estates, which produce all the necessaries of life, and afford a surplus for the payment of taxes and the purchase of luxuries. They are exceedingly well lodged, and the families live abundantly; the manner of living, indeed, is pretty much the same amongst all classes. These, and the comfortable assurance that in case of death the udalman leaves his wife and family provided for, are certainly calculated materially to promote human happiness. "This class," says Mr Laing, "are the kernel of the nation. They are in general fine athletic men, as their properties are not so large as to exempt them from work; but large enough to afford them and their households abundance, and even a superfluity, of the best food."

Besides the bonder, or agricultural class, properly so called, who occupy all the most fertile lands in the country "from the shore-side to the hill-foot," whereon corn will grow, there is another class called fjeld bonder, who form a connecting link, as it were, between the class above described and the wandering Laplander. They also possess land, and have houses which, although small, are comfortable; but being above the level of the corn-growing country, their situation is not so favourable, nor is their condition equal to that of the other small proprietors. The fjeld bonders are "the hewers of wood and drawers of water" in Norway; but they still possess property in cattle as well as in land, and they are described as extremely hardy and active, and as having more robust frames than the agricultural bonder. There is yet another class of the population which is altogether distinct from any of the preceding, consisting entirely of fishermen, whose social condition must be considerably inferior to that of the others. Norway.

In the provinces of Nordland and Finmark, which occupy the northern part of Norway, beyond the River Namsen, agriculture is but a secondary business, and fishing may be said to occupy most of the attention of the inhabitants. Indeed, a Norwegian writer says, that were it not for the Norwegian fishery, the whole of Finmark and a part of Nordland would be inhabited only by nomad Finns, and the towns all along the coast would languish and disappear. The crops of grain are too inconsiderable and precarious to afford them the means of subsistence, and the riches of the deep are brought in as a compensation for the poverty of the land. The winter fishery in the Lofoden Islands, from the middle of January to the middle of April, and the summer fishery over all the coast, which in some branch or other gives employment for the remainder of the year, furnish the inhabitants with the means of purchasing the necessaries which they require. Fishing.

The *Oxonian in Norway*, by the Rev. F. Metcalfe, published in 1856, gives a very complete account of the Lofoden fishery; and from that work we extract the following particulars:—The fishermen begin to arrive in open boats from all parts of Norway soon after New Year's Day, and take up their positions along the coast, from Balstad on the W., to Bretesnes on the island of Great Molle on the E. In each boat there are generally five men, one of whom commands and takes the helm. At Henningsvär, a favourite station, as many as 900 boats congregate; and it is computed that there are at least 3500 boats, giving an aggregate of 21,000 men, employed exclusively in fishing. Besides these, there are numberless *jaegts* and *jagts*, belonging to merchants from far and near along the coast, which come to buy oil and fish, and sell groceries, &c. At Svolvär alone there were no fewer than 140 of these vessels. The fishermen live in huts along the shore, which, together with the permission to fish, they hire of the proprietors of the adjoining land at certain rates fixed by government. If the morning is fine and the weather suitable, the government officers appointed for that purpose hoist the requisite signal, and the boats go out and set their nets and lines generally at right angles to the run of the coast. If the weather is bad, no signal is hoisted; and every one venturing out under those circumstances is liable to a fine of 5 dollars, and to have all his fish seized. Most of the day is consumed in fishing with a hand-line and in taking up the nets and long lines. On getting to shore, the fish are gutted and hung up to dry on poles and cross-bars, which they hire of the proprietors along the coast. These are stock-fish (so called because they are dried on stocks or poles), and are unsplit. Others, which are sold to the owners of the jaegts, are split open, salted down, and packed flat in the holds of these vessels. On obtaining a cargo, they leave for home; and on arriving there, the fish are taken out of the vessel, washed, and dried upon the rocks. These are klip-fish—*i.e.*, rock-fish. The laws of Norway are very stringent regarding the preparation of the stock-fish. None are allowed to be taken down before the 12th of June, nor are any allowed to be hung up after the 14th of April. There is a fine of 2 dollars on every hundred fish taken down or hung up before or after the above dates respectively. Everything is managed according to strict rule, and under the surveillance of government officers. During the period of the fishery no steamer is allowed to come near, for fear of driving away the fish. All the fish caught after the 14th of April are prepared as klip-

Norway. fish; but the fishing is virtually over then, and the men leave the Lofodens, returning, however, in the course of the summer to take away the stock-fish. The cod-liver oil so extensively used in medicine is prepared from the livers, which are put into barrels brought from home for the purpose, or sometimes sold to merchants on the spot. The best oil is that which exudes from the natural fermentation of the liver. Cod-liver oil is not obtained solely from the cod-fish, but also from others, as the shark, the ling, and especially the sei or coal-fish, its liver being richer in oil than that of the cod. It is caught in large quantities in summer, especially in the Bay of Varanger. Cod-liver oil costs on the spot from 5 to 6 dollars the barrel of 120 pots, and a wine-bottle holds about three-fourths of a pot; so that, in round numbers, at the highest price, it costs about 1s. the imperial gallon.

All the towns export fish. Bergen exports more than one-half the stock-fish; but of late the Romsdal towns, as they are called, have become dangerous rivals to it in the klip-fish trade. Half the oil goes from Bergen. There is still a heavy export duty on all kinds of fishery products. About L.6000 are also raised annually by the duty on salt, the greater part of which is used in curing the fish. Until 1851, a tithe of all the fish and oil was paid to the church of the district; but instead of this tax, which was very vexatious, and led to numerous disputes and much dishonesty, an extra tax of two skillings per waag (36 lb.) is levied on all fish exported; while on oil the additional duty is 12 skillings (5d.) per tonde (30 gallons). The value of the different kinds of fish annually exported is estimated at about one million sterling. The quantities are given in a subsequent table.

Besides these important general fisheries, there is in every creek of the fiords, even at a hundred miles up from the ocean, abundance of cod, whitings, haddocks, flounders, sea-bream, and herrings, caught for daily use and for sale by the seafaring peasantry. The rivers and lakes are likewise well supplied with fish (the former with salmon), which may indeed be said to constitute the basis of a Norwegian repast. Dried and salted fish is sent in great abundance to the Mediterranean, and also to Hamburg and Holland. Lobsters are caught among the rocky islands in immense numbers for the supply of the London market. Anchovies are also caught in prodigious quantities.

Manufactures and commerce. The manufactures of Norway are too unimportant to detain us long. Wood and fish are the chief produce of the country; and these find their way to every part of Europe, chiefly in Norwegian vessels, which in return bring home whatever foreign articles are required, at the cheapest possible rate of freight. The import duties are very moderate. Before the importer pays his duties, he is allowed to take his goods to his own warehouse and shop, upon giving security for the amount of the duties ascertained by the custom-house officers at landing; he also keeps an account of his sales, and pays the duty every three months upon the quantity which appears to have been sold. This must be of great advantage to the dealer in a country so poor as Norway, since it leaves his capital entirely free for active employment. Coffee, sugar, tea, French brandy, and French and Spanish wines, tobacco, and a limited quantity of spiceries, are the principal articles for which the housekeeper has to disburse money. The other necessaries of life are produced by themselves. Shoes, furniture, cloths, and the like, are all made at home. Looms are at work in almost every house in the country; carding, spinning, and weaving forming constant occupations of the female part of the household. Woollen cloth, substantial but coarse, excellent bed and table linen, and checked or striped cotton or linen for female apparel, are the ordinary fabrics produced. These home-made stuffs, including boots, gloves, and in bad weather great-coats, clothe the greater part of the inhabitants, and more comfortably than is the case with the lower and middling classes of people in most other countries. The upper ranks, or the people of condition, dress as in other parts of Europe; and as living and lodging are nearly on a level amongst all the respectable classes, the peasant proprietor, and those more wealthy than he is, this wearing of foreign articles by the latter, and home-made stuffs by the former, would seem to constitute a kind of conventional distinction between them. Norway.

The principal articles of export are timber, bark, iron, copper, fish, and some others. The principal articles of import are corn; colonial produce; woollen, linen, and cotton goods; wine; brandy, &c. The following is the quantity of fish exported from Norway in the year 1855, viz.:—

Stock-fish.....	tons 16,374	Cod-Liver Oil ...	barrels 78,804
Klip-fish.....	„ 22,318	Anchovies	kegs 11,737
Cod Roes.....	barrels 30,668	Salmon, smoked.	lbs. 4,551
Herrings, salted...	„ 519,868	Salmon, salted...	barrels 77
Other Fish, salted	„ 3,040	Lobsters, live...	number 814,188

In the year 1854, 31,000 quarters of oats were exported, which Mr Crowe states is unparalleled in the annals of the trade of Norway, but is likely to be repeated, as the province of Hedemarken, which is now brought into connection with the capital and sea-coast, is pre-eminently suited for the growth of that cereal. The total amount of cereals imported in 1851 was 631,390 imperial quarters; in 1852, 602,110 do.; in 1853, 567,192 do.; in 1854, 425,975 do.; and in 1855, 492,591 do.

Mr Crowe further remarks that there has been a general increased importation of many articles, attributable to the prosperity of the country and the reduction of duties on a variety of articles entering largely into their domestic economy.

The deals of Christiania have always been held in the highest estimation; a consequence of the excellence of the timber, and of the care with which the sap-wood and other defective parts are cut away. Like many other branches of the trade of Norway, that of preparing wood was formerly fettered by pernicious restrictions; the saw-mills being licensed to cut a certain quantity only, and the proprietors bound to make oath that it was not exceeded. But this absurd regulation no longer exists.

The following is a return of timber and deals of every description, exclusive of deal-ends for splitwood under 20 inches long, lathwood, &c., exported from Norway in the years specified, viz.:—

	Loads.		Loads.
1851 ...	632,727	of which there were sent to Great Britain	165,024
1852 ...	701,462	„ „ „ „	182,879
1853 . .	775,845	„ „ „ „	246,646
1854 ...	743,468	„ „ „ „	236,247
1855 ...	737,557	„ „ „ „	217,915

The amount of wood under 20 inches, called splitwood, exported to Great Britain in 1855 was 40,980 loads.

British manufactured goods are admitted into Norway on moderate duties, and are very generally made use of.

Weights and measures. The weights and measures of Norway are the same as those of Denmark. With regard to money, the principal silver coin in circulation (for there are none of gold) is called a species dollar, which is divided into one hundred and twenty skillings. There are also half species, one-fifth species, one-tenth species, one-twentieth, and what is denominated *skillemynt*, or small change—that is, four and two skilling pieces of silver, and also one-half, one, and two skilling pieces of copper. The dollar is worth four shillings and fourpence three farthings sterling at the present rate of exchange. There are, besides, notes of one dollar, half a dollar, and twenty-four skillings, all printed on white paper. The notes of five dollars' value are on blue paper, those of ten dollars on yellow paper, those of fifty on green paper, and those of one hundred on red paper.

Revenue. The Norwegian finances are in a flourishing condition, the revenue having latterly increased considerably. The

Norway. Bank of Norway, which was founded in 1816, has its head-office in Trondhjem, with branches in the principal towns, and is under the direction of five stockholders, with a council of fifteen representatives of the other proprietors. The transactions of this bank are conducted upon a principle totally opposite to that of the Scotch and other banking establishments. It is there considered as a first principle that the bank should hold only available securities, as bills or bonds at a short date, or payable at a short notice, for its issues or advances. The national bank of Norway is therefore a bank for landed property, and discounts mercantile bills and personal securities only as a secondary branch. Its chief business is advancing its own notes, upon first securities over land, any sum not exceeding two-thirds of the value of the property, according to a general valuation made in the year 1812. The borrower pays four per cent. for what he draws, and is bound to pay also five per cent. of the principal yearly. This kind of bank is exceedingly well adapted for the wants of the country; and their paper can scarcely be considered as less secure than their silver.

Army. The Norwegian army consists of some 24,000 troops of all arms. Two companies belonging to each regiment in the Norwegian service are trained to the use of the skidor or skate. This corps, called the skielöbere, move with singular agility and speed, and, whilst skating along with the greatest velocity, perform their military evolutions with uncommon precision. The army is at the disposal of the king, as far as its services can be rendered available in Scandinavia; it cannot, however, be sent beyond the limits of the peninsula without the special permission of the Storthing. The king has the nomination of the superior officers of the army, as well as of some few of the first civil officers under the government; that of others rests with the Storthing. Norway is governed by a viceroy, appointed by the King of Sweden; Christiania, the capital of the country, being the seat of government. She contributes nothing towards the expense of the Swedish government, beyond a trifling annual allowance to the royal family; but she supports all her own civil and military institutions.

Navy. The Norwegian navy consists of 3 frigates, 5 corvettes, 4 brigs, and 124 gun-boats. They have also 13 steam-vessels of war, of, in all, 1490 horse-power, the largest being of 200 horse-power. Nine of these are employed in the royal mail service, under the command of naval officers. During the summer months three ships are usually commissioned for a summer's cruise with cadets.

The officers of the Norwegian navy consist of a rear-admiral and 6 commodores, 12 captains, 12 lieutenant-captains, 24 first lieutenants, 35 second lieutenants, and 64 petty officers; besides 100 cadets, and 120 artillery cadets. In case of war, every male is bound to serve a certain period either in the army or navy; and there are about 50,000 seamen, whose names are on the registers, liable to serve.

There is a great difference in the pay of the navy and merchant service, the latter being more than double; but, as in our own case, the seamen are far better fed and provided for in the naval service. The merchant seamen are generally engaged either in the transatlantic or North Sea and Mediterranean timber trade, or in the fisheries. They are described as amongst the hardiest and best race of seamen in the world, and accustomed to live on coarse fare, and put up with many hardships to gain their livelihood.

The mercantile marine of Norway has greatly increased within the last few years, as appears by the following return:—

	No. of Vessels.	Tonnage.	Crews.
1851	4496	412,437	24,057
1852	4742	427,234	25,388
1853	4893	454,856	26,545
1854	5129	501,860	28,063
1855	5241	538,964	28,638

Vessels of all nations now trade with Norway, and her ships are to be met with in every foreign port. Mr Crowe, the intelligent consul-general at Christiania, remarks that "a few years ago, the Norwegian flag was scarcely ever seen beyond the confines of Europe; now it waves in every part of the globe." Norway.

Some very interesting and elaborate statistical tables connected with the population and productions of Norway, compiled from government sources, was published in Christiania in 1857. From these it would appear that the following is the total amount of the population in 1855, viz.:—

Province of	Christiania	643,135
,,	Christiansand	244,413
,,	Bergen	242,914
,,	Trondhjem	227,343
,,	Tromsöe	132,242
	Total	1,490,047

The following is the amount of the population at various former periods:—1769, 723,141; 1801, 883,038; 1815, 885,431; 1825, 1,056,318; 1835, 1,194,827; 1845, 1,328,471; and 1855, 1,490,047.

The increase of population has chiefly taken place amongst the agricultural classes; and the additional food raised for their support, together with the advance of the people, is to be attributed partly to additional tracts of land having been taken in, and partly to improved methods of cultivating the old soil.

Political divisions. The kingdom of Norway is divided into five sees or stifts, each of which is divided into a certain number of districts, corresponding to its size and importance, and these again into parishes, of which there are 336 in the country. The dioceses are—Christiania, containing Christiania, the capital; Christiansand, the largest town in which bears the same name; Bergen, containing the large and important city of the same name; Trondhjem, which contains the city of Trondhjem, situated on the south shore of a great fiord of the same name; and Tromsoe, comprising the northern territories of Nordland and Finmark. The stifts are thus distributed:—Christiansand occupies the southern extremity of the country; Bergen and Christiania occupy, the former the western, and the latter the eastern side of Norway, where it is widest, extending over its whole breadth in that quarter, and being separated by the great mountain chain; still further north lies Trondhjem, which is succeeded by Tromsoe, the most northerly region of Norway, and of which the reader will find some account in the article LAPLAND. Each district, called a fogderie or bailiwick, is under a foged, who has charge of the collection of taxes, police, and all executive functions in his district. Besides this public functionary, there are military officers, who have official residences in the district; and the amtman, and sorenskriver or judge ordinary. Christiania, Bergen, Trondhjem, and the other large towns in Norway, will be found described under their own respective heads.

Political constitution. The Norwegians enjoy more political liberty than any other European nation. The parliament, called the Storthing, is chosen by the owners or life-renters of the land who have attained the age of twenty-five years complete. The minimum value which gives a vote is 150 dollars, or L.33; a value which, from the large diffusion of property, renders the suffrage nearly universal. To render the elector himself eligible as a representative, it is only necessary that he should be thirty years of age, have resided ten years in Norway, and be altogether unconnected with the state. The voters choose electing men, 1 to every 50 voters in towns, and 1 to every 100 voters in counties. The electing men, on a day fixed by law, choose their representatives, and the body thus elected forms the Storthing. The proportions of members chosen is founded on the principle that the towns in Norway should as nearly

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as possible return one-third, and the country two-thirds of the whole body, which must not consist of less than 75, nor of more than 100 members. Each district elects as many substitutes as it elects representatives, to provide against death and other casualties. The Storthing is chosen every three years, and is assembled only once in three years, when it sits for three months, or until the business be despatched. The 1st of February is the day of meeting fixed by law. An extraordinary Storthing may be convened by the king, but its acts must be confirmed by the next regular Storthing. After some preliminary business, such as electing a president, speaker, and secretary, the Storthing divides itself into two chambers. One-fourth of its whole number is formed into a second chamber, called a Lagthing, or division, in which the deliberative functions of the legislative body are vested. No bill can be introduced there; it must come from the other house, which is called the Odelsthing, or House of Commons. The Lagthing can only deliberate upon what is sent to it, and approve, reject, or send back the bill with proposed amendments. It is also the court before which, aided by the Hoieste Ret Court, an independent branch of the state, the lower house may impeach ministers of state. The Storthing consists, in fact, of three houses —the Lagthing, the Odelsthing, and the entire Storthing. In this latter all motions are made and discussed; and, if entertained, are referred to committees to report upon to the Storthing. The report, when received back from a committee, is debated and voted upon; and, if approved, a bill in terms of the report is ordered to be brought into the Odelsthing. This house entertains or rejects the proposed bill, frames and discusses the enactments, if it is not rejected *in toto*, and sends it up to the Lagthing or upper house, to be deliberated upon, approved, rejected, or amended. In regard to the passage of bills through these two houses, the practice of the Norwegian Parliament does not differ materially from that of our own, except in the more limited functions of the Lagthing, the king having only a suspensive veto. But if a bill pass through three successive Storthings, it becomes the law of the land without the royal assent. This was exemplified in the case of the bill, already mentioned, for the abolition of hereditary nobility. The duties of the Storthing need not be minutely specified; they may easily be inferred. The members are paid for their services; and no executive officer of government can sit in either house. The clearest and most concise account of the constitution of Norway will be found in Mr Forester's *Rambles in Norway*, published in 1850, and in Mr Brace's *Norse-Folk*, published in 1857.

Jurisprudence.

For legal purposes, the whole country is divided into five stifts or provinces, and these are farther subdivided into 17 amts and 64 judicial districts, each of which last comprehends several prestigilds or parishes. To each of these divisions there is a distinct tribunal, with a supreme court of ultimate appeal for the whole kingdom, established at Christiania. The lowest court, which is strictly one of equity, not of law, is the court of mutual reconcilement or agreement held in every parish, and over which presides a commissioner, who is elected every three years by the householders, and holds his court once a month, receiving a small fee. Every case or lawsuit whatsoever must pass through this preliminary court, where no lawyer or attorney is permitted to practise. Each party states his own case; and if by the judgment or advice of the commissioner the parties are brought to agree, his opinion is duly registered in another court held in the parish, and it has all the validity of a final decision. If, however, the litigants are not satisfied, they carry their case to the lowest legal court, that of the sorenskriver, or sworn writer, which is held in every parish of each district once in every quarter. The sorenskriver's court is of great importance. Besides judging civil and criminal matters, it is the court of registration affecting property in the district, and also of ascertaining the value of, and succession to, the property of deceased persons. The court next above is the stift-amt court, or that of the province, and is thus constituted: It consists of three judges with assessors, is stationary in the chief town of each province, and is the court of appeal from all the lower tribunals of the province, having at the same time the revision of their administration. It must likewise sanction their decision in criminal matters before sentence can be pronounced. There is, lastly, the Hoieste Ret Court of final appeal. It consists of seven judges, and, by the ground law, is one of the three estates of the constitution, being independent of the executive and legislative branches. To this court appeals are carried in the last resort, from the stift-amt courts, in criminal as well as civil cases.

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The Norwegian system of jurisprudence presents some remarkable features, not the least important of which is, that the judge is responsible for his legal decision; and in a case of appeal to a higher court, he must there defend his judgment, being liable in damages for a wrong decision. This principle involves a high responsibility, and must occasion some individual annoyance, as well as expense; but it does not prevent able lawyers from becoming candidates for judicial functions; and beyond all doubt it is of great advantage to the public in giving certainty to the law, and in preventing as well as remedying erroneous decisions. The punishment of death was abolished by the Danish government about the latter end of the last century, a measure of questionable expediency in this country, at least where the secondary punishments are by no means perfect. But the punishment which is found the most effective, and which forms one of the most distinguishing characteristics of the country, is that of the "loss of honour." From the earliest times this has been a specific punishment in the criminal law of Norway, standing next in degree to the loss of life. There is, and always has been, much more of the real business of the country in the hands of the people of Norway, and transacted by themselves, than is possessed by the inhabitants of any other European nation. Now, as the "loss of honour" involves exclusion from all the functions which naturally devolve upon them, the punishment is very severely felt, and looked upon, even by the humblest peasant, with the greatest dread.

Church.

The Norwegian Church is in principle and doctrine Lutheran, and remains as it was originally moulded after the subversion of the ancient faith, unaltered by the spirit of innovation, and unviolated by the hand of power. It is essentially ceremonial, and has been considered by some almost as much so as the Roman Catholic. Mr Forester, however, justly observes, that such persons look only at the surface of things. "They have been startled," he says, "by the array of images on the altar, the display of rich vestments in the celebration of the eucharist, and the use of the unleavened wafer, together with a high degree of reverence, accompanying the administration of that sacrament; and from these appearances have been led to conclusions which are by no means justified." "It would be more correct to say that the public worship of the Lutheran Church essentially differs from the Roman Catholic, and has a close affinity to that of the Church of England. It is, indeed, ceremonial and liturgical. . . . . But there is nothing superstitious in her ceremonial; and her ritual, like our own, contains nothing that is contrary to the Word of God." The altar of the Norwegian Church is decorated with crosses and images, and the priest, arrayed in embroidered robes of velvet, celebrates high mass under that name. There are in Norway 336 prestigilds or parishes, and many of these are exceedingly large, extending in some parts from the sea-coast to the Swedish frontier, and containing from 5000 to 10,000 inhabitants. This is certainly a low provision for religious instruction; but the people, generally

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speaking, are scattered all over the country, not clustered in towns and villages; and although individually they are not affluent, they are at least respectable, notwithstanding that as a whole they are poor. Under such circumstances parishes must necessarily be large. There are five bishoprics in Norway, each of which has in it a number of inferior clergy. The patronage is in the hands of the five bishops and the council of state, a committee of which has charge of all the affairs of the church. The incomes of the clergy are derived from tithes, commuted into a payment of grain, glebe farms (one of which the widow has for her life), offerings, and dues. These incomes in country parishes vary from L.150 to L.350; but in large towns or thickly-settled parishes they are higher. The bishops have about L.800 to L.900 each. In proportion to the other professional classes in the country, the clergy are well paid, and the church has always been the first profession to which talent is naturally directed. The clergy are laborious and zealous in the discharge of their duty, the church service forming the smallest part of it. They have school examinations, Sunday schools, and other institutions for the promulgation of Christian knowledge. It is a peculiar characteristic of the Norwegian Church that there is no dissent from it; there are no sectarians in the country. In political rights and privileges the clergy are on a footing with the rest of the inhabitants, and are represented in the Storthing like other citizens. One chief cause of the influence of the ministers of religion, and the absence of dissent, is the high consideration in which the right of confirmation is held. The person who has passed this ordeal is regarded as having received a moral as well as a religious diploma, which capacitates him for an office of trust and responsibility.

Education.

There are few countries, perhaps, where education has of late years been more attended to than in Norway. In all the large towns there are public schools, and academies and schools for mechanics and artizans. The latter are called drawing-schools, of which there are eight, where mechanics are instructed in modelling, drawing, mathematics, &c. In the diocese of Christiania alone, Mr Brace tells us, that there are no less than 197 stationary schools, besides a high school. In many of the towns there are charity schools, where the children of the poor remain during the day, while their parents are at work. These are supported by public and private contributions. Education is very generally diffused; but great difficulties exist, owing to the population, though not numerous, being so scattered. In the country parishes there are parochial schoolmasters, of whom some have fixed residences, and others live for one-half of the year in one place, and for the other half in another. A small tax is levied from each householder, and every adult pays a small personal fee. There is a considerable degree of intelligence evinced in some of these communities; but the schools are too widely scattered over a thinly-peopled country to be equally beneficial to all. It may be mentioned, that the clergy pay particular attention to the diffusion of education. The higher department of university education at Christiania is expensive; and, besides, there is not such a demand for educated men in the medical, legal, and commercial professions, as in more densely peopled and commercial countries, the tendency of which undoubtedly is to raise the standard of intellectual proficiency amongst all classes of the community. Those belonging to the learned professions are not numerous, because the demand is not great, and the supply is adjusted accordingly. The restrictions on the free exercise of trade and industry also operate with great force in depressing general education. Before a person can enter upon any medical or legal employment, before he can manufacture, buy, or sell as a merchant, he must obtain peculiar privileges from a corporate body. "As the expense of preparation," says Mr Laing, "and the small number of prizes to be obtained, place the higher and learned professions out of the reach of the main body of the people, as objects of rational ambition, for which they might endeavour to bestow superior education upon their children; so the restrictions and monopoly system shut them out from various paths and employments for which ingenuity, with ordinary useful education, might qualify them."

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The press.

From the general diffusion of periodical publications, the Norwegians are a reading people. What is of great importance to the community is, that the press is by law perfectly free. There is no duty on newspapers. Every little town has its local newspaper; and from the importance attached to local subjects there discussed, the bulk of the community are the purchasers, not the educated few. In type and paper they are superior to the French or German papers, and much ability is shown in conducting them. There is no scurrility nor personal abuse displayed by those who write in them; yet the most entire freedom of discussion exists, public men and public measures being handled freely but decorously, and with a strict eye to the general good. Several monthly journals are devoted to literature, antiquarian, agricultural, and military subjects; and in almost every newspaper there is the announcement of some new work or translation. Yet the literature which ought strictly to be considered as Norwegian is not yet of a very high order, compared with that of other countries. But the mind of the country is advancing, and literature, which is young in Norway, will advance along with it.

Manners and customs.

The inhabitants of Norway are very polite in their manners, as well to each other as to strangers. There is a natural *bonhommie* among the peasantry which is very agreeable to meet with; shaking your hand for the smallest benefit conferred upon them, even for the payment of what is their due. They are partial to theatrical representations, so that the drama holds a high place in their estimation; and, besides the public theatres, there are societies of amateur performers in all the larger towns, and even in some of the villages. In music, dancing, and dress, the Norwegian females are by no means deficient. They have pleasing voices, and in every family of every station singing and dancing are constantly practised in the long winter evenings. Music is taught in the country by the organist attached to each parish. In the winter regular fairs are held, at which Swedes and Laplanders attend for disposing of goods. Mr Bayard Taylor tells us, in his *Northern Travels*, that at Raubyen, which is a large village, with a stately church, the people were putting up booths for a fair in Lat. 65. N. in the open air, with the mercury freezing. Christmas is kept in great style, and there are other festivals and various amusements which serve to relieve the tedium of winter and spring. The 17th of May, also, being the anniversary of their independence, is celebrated both at home and abroad by every Norwegian, and with marked propriety. Mr Laing gives a favourable account of the state of morals in Norway; but, without impugning so high an authority, if we are to take bastardy as a test, the statement is not borne out by the facts. The proportion of illegitimate to legitimate children is as 1 to 10; but the evils entailed upon society by illegitimacy are partially alleviated by the state of the law in respect to this. Children are not only rendered legitimate by the subsequent marriage of the parents, as in Scotland, but the father, previously to his contracting a marriage with another party, may, by a particular act, legitimize them. The Norwegians are, at all events, a very hospitable, honest, industrious, peaceable people, and the great mass virtuous in the opinion of all travellers.

Charitable institutions.

Norway is not deficient in her charitable institutions. Mr Brace, in his work entitled *The Norse-Folk, or a Visit to the Homes of Norway and Sweden*, considers Bergen as the most conspicuous town for its institutions of charity. He states, that with a population of 28,000, it appropriates

L.6500 per annum to the poor and sick, besides the sums for public institutions. There are the Old Sailors' Asylum, 120 inmates; the Widows', 31 inmates; the Old Warders', 30; the Old Citizens', 60; Leprous Hospital, 600; Hospital, 120; Insane Asylum, 50 inmates. The mode of disposing of the vagrant and criminal children is similar, says Mr Brace, to that adopted by private organization in his own country (America),—"the sending them to individual homes in the country, where responsible parties are bound to support and educate them. There seems to be a very regular and exact visiting of the poor by public inspectors, who are bound to serve without pay for four years. These report if the children do not attend school, or are vagrant, or falling into criminal habits; they also dispense assistance, and give permits for the different asylums and institutions." At Christiania there is an institution for vagrant and houseless girls, the Eugenia Stift, which, the same author tells us, seems excellently managed; and a new insane asylum, "a large building arranged on the best modern principles. There is no wall about the asylum, and the view is exquisite, enough in itself to be a cure for the diseased mind."

Public improvements.

The government of Norway, aware of the value and importance of steam navigation, has made great and judicious exertions to promote it. This is a country where it is calculated to produce its greatest benefits, from the manner in which the peninsula is traversed by long arms of the sea, penetrating sometimes to its very centre. Steam-vessels are now seen plying on these fiords, and during the summer months they navigate the whole coast from Christiania to the North Cape. They are commanded by naval officers; the fares are moderate; and in all that regards the comfort of passengers they rival our own. Roads and bridges are kept in a state of excellent order; a circumstance likely to happen in a country of proprietors, whose common interest it is to keep them in repair. There are no tolls in Norway; the principle of the farmers and others is to work in concert, and to keep up establishments for the common benefit. A railway, the only one in Norway, not long since opened, runs from Christiania to Eidsvold, and will be continued to Minde, at the foot of the Miosen Lake, a distance of 50 or 60 miles. A steamboat thence plies to Lillehammer, at the head of the lake, a further distance of about 70 miles, thus opening a direct communication to the sea with one of the most productive parts of the interior. The easiest approach from England to Norway is from Hull, whence there is a weekly steam communication with Christiansand during the summer months; but to those not fond of the sea, the best route is by Calais, and, taking the rail through Hanover, Hamburg, and Kiel, proceed by steamboat to Korsos, and again by rail through Zealand to Copenhagen, whence there are steamers through the Cattegat to Gottenburg and Christiania. Many of our countrymen now visit this delightful country.

The worst feature, perhaps the only thoroughly bad one in the institutions of Norway, is, that the trade is not free Each trade is monopolized by a sort of guild or fraternity, by which even country dealers are licensed. The pernicious effects of such a system are sufficiently manifest, and we shall close our account of this interesting country with the following observations, extracted from a work of great authority on such subjects:—

"The principle of equal partition of land among all the children, retained in Norway from the earliest period, prevailed also in England before the Conquest. A relic of it remains in the law of gavelkind, still existing in Kent. The different effects produced on society by the retention of that law in the one country, and its general disuse in the other, are remarkable. In Norway, chiefly by its operation, a high standard of sufficiency has been preserved among the middle and labouring classes. Population has been prevented from increasing too rapidly by the fear which people have of falling below the general standard. There has, therefore, been a continual prevalence and diffusion of ease and wellbeing. But on account of the absence of great inequalities of condition, and therefore of many of the usual stimulants to exertion, society has been kept at a low level. Great social freedom has indeed always existed, in consequence of the land being in the hands of the mass of the people; but there has been a want of ability, until a very recent period, to combine for the preservation of their political independence. During their earlier history, their political liberties were often variable and uncertain. After the union of their crown with that of Denmark in 1380, it appears that the Danish nobility gradually encroached upon their privileges; for when, in 1660, the crown and the people combined against the nobility, and abolished the states in Denmark, a similar revolution also took place in Norway; and that country continued under absolute government until the establishment of its constitution in 1814. Their udal laws trained them in the management of their own affairs, and produced that feeling of self-respect which the possession of property, and of land in particular, is calculated to give. These, together with the civil institutions preserved or introduced whilst they were under the Danish crown, prepared them for the large measure of freedom to which they have now attained. The evil of their udal system is its tendency to obstruct the development of intellect, and to keep society stationary. But since 1814 they have made great progress. Stimulants to mental activity are now no longer wanting. Their continual collision with Sweden, the problem of their internal restrictions on trade and commerce, the routine of their government, and the wholesome struggles always arising in a free state, will supply them. Their land will become more productive, by the application of science to its cultivation; their trade will also be expanded." (*Edinb. Review*, No. cxxxi., p. 60.) (J. F. S.) (J—N B—W.)

History.

NORWICH, a city of England, and the capital of the county of Norfolk, stands in 52. 42. N. Lat., and 1. 20. E. Long., 108 miles from London.

Modern archæologists agree in regarding Norwich as the *Venta Icenorum* of the Romans, called *Caer Guntum* by the British, and afterwards *North-wic* (north town) by the Angles, the tribe which peopled *Northfolk* and *Southfolk*. As the capital of the Iceni, it was without doubt an important place long prior to the advent of any of these foreign conquerors, the castle being the royal residence of British kings, and most probably of Boadicea. At a later date it became the metropolis of East Anglia, and we have records of the residence of Uffa, Anna, and other royal personages, at the castle. The original structure, however, fell a sacrifice to the Danes, who completely overran this district, under Sweyn. It was rebuilt by Canute; and again suffering injury, was so entirely renovated, if not wholly rebuilt, at the time of the Norman Conquest, as to present no vestiges of any other architectural features than were common to all the Norman edifices. The earthworks of the castle-hill, however, bear traces of early British construction; and utensils that have been dug up bear testimony to the presence of the Romans at some period. The military fortification at Caistor, about three miles distant from the castle, which, until recently, was considered the *Venta Icenorum*, is now pronounced to have been the Roman camp, placed there, as it were, to guard the British settlement at Norwich. In 1049 Norwich was created an earldom by Edward the Confessor. In Domesday Book the city or borough is stated as having 1320 burgesses with their families, 25 parochial churches, and between 800 and 900 acres of land. In the reign of William Rufus, the episcopal see was removed thither from Thetford by Bishop Herbert, who in 1096 laid the first stone of Norwich cathedral. Henry I. granted the city a charter containing the same franchise as the city of London then enjoyed, and the government of the city was then separated from that of the castle, the

Norwich. chief officer being styled *Præpositus*, or Provost. From the time of Henry I. to Edward III., the liberties of the city were often suspended, and gradually enlarged. A colony of Flemish weavers, who had settled at Worstead in the reign of Henry I., first introduced the woollen manufactures; a second colony settled in Norwich in the reign of Edward III., and the city was made a *staple* town for the counties of Norfolk and Suffolk. These causes, combined with the sumptuary laws of Edward III., greatly promoted its commercial prosperity. Grand tournaments were held, at which at various times the kings Henry III., Edward I., and Edward III. and his queen Phillippa, were present. Edward the Black Prince was also present at a tournament in 1350. The castle, which had been used as a place of confinement for prisoners under the earls, was, in the fourteenth year of the reign of Edward III., given over entirely to the sheriff of the county, and from that time was used wholly as a county jail. In 1403 the city was separated entirely from the county of Norfolk, under the name of the county and city of Norwich; and the first mayor was elected by the citizens. In 1422 the doctrines of the Reformation made their appearance in Norwich; and several persons were executed as Wickliffites or Lollards. A large chalk-pit on the outskirts of the city is to this day known as "Lollards' Pit," from having been the scene of these persecutions, which continued at intervals until the reign of Edward VI. Among the list of martyrs is the name of Thomas Bilney, who was burned in 1531. In 1549 the city was the scene of an insurrection resembling that of the Jacquerie in France and the Peasants' War in Germany. The facts of this local rebellion were simple enough. The poor objected to the inclosure of certain commons and waste lands in the neighbourhood of Attleborough and Wymondham; fences were thrown down; Robert Kett alias Knight, a tanner, a bold and resolute man, headed the rebels, aided by his brother William, a butcher. Their numbers increased, and, marching towards Norwich, they encamped on Mousehold Heath, took possession of the mansion of the Earl of Surrey, and thence proceeded to lay siege to the city. They held courts of justice under a large tree, called the "Oak of Reformation;" and having augmented their numbers from the citizens to 16,000, and strongly fortified their camp, they summoned the city to surrender. For months they maintained hostilities, and the country round was pillaged and laid waste, until at length they gained an entrance to the city, and bore off the mayor and several of the corporation prisoners to their camp. A strong force was sent down for the defence of the city, under the Marquis of Northampton. A regular engagement was fought at the base of the hill, on St Martin's Palace plain, in which Lord Sheffield, a nobleman engaged in the strife, was slain. The rebels prevailed, and forced the marquis to retire, and on his retreat, plundered and set fire to the city in many parts. The Earl of Warwick, assisted by his son Robert Dudley, Earl of Leicester, was then sent to the relief of the citizens. The city was again stormed by the king's troops, and the rebels forced to retreat, after two days' sharp conflict, during which upwards of 3000 were killed. The insurgents were subdued. About 300 of the ringleaders were executed, and the two Ketts were sent to the Tower of London, and being both convicted of high treason, Robert was executed on the top of Norwich Castle, and William on Wymondham steeple.

Norwich, in common with all Norfolk and Suffolk, took up the cause of the Reformation with a vehemence which causes them to stand alone in the annals of history, and has ever preserved the same spirit of progress and independence amongst the masses, amounting to democratic tendencies and tastes. In Elizabeth's reign the burnings of the Roman Catholics rivalled the flames which had been fed by Protestants in former reigns, and martyrdoms for heresy of doctrine, even among Protestants themselves, were far from being uncommon. In 1578 the queen visited the city in person, and very grand doings celebrated the event. During the Commonwealth the city was put in defence against the royal cause, the castle was fortified for the service of Cromwell, the goods of the bishops and clergy sequestered, the bishop's palace sacked, the cathedral and churches plundered and defaced, and Bishop Hall turned out and driven into retirement. In 1645 the city was divided into presbyteries, and the observance of Christmas-day abolished by command. At the Restoration the city was amongst the earliest to do homage to King Charles. In June 1660 the fee-farm of the city was resigned to him, with a present of L.1000 in gold; and in 1663 the charter of the city was renewed and enlarged. In 1671 the king visited the city, and was entertained most hospitably. In 1701 the art of printing, which had been discontinued for many years, was revived, and newspapers began to be printed. Few other events of historical interest have distinguished the city, apart from its progress in manufactures.

Manufactures. It has been already stated that woollen manufactures were commenced in the city by a colony of Dutch weavers in the reign of Edward III. In the reign of Richard II. they declined; discontent reigned throughout the kingdom; and Norwich shared the general lot of devastation and plunder at the hands of armed bands, 80,000 in number, under Litester, a dyer. In Elizabeth's reign trade revived, through the invitation given to the Dutch and Walloons, then fleeing from the persecutions of the Duke of Alva. Thirty of those were invited to Norwich, all of them experienced workmen, each to bring with him ten servants, to be maintained at the expense of the Duke of Norfolk. These multiplied, until their numbers exceeded 5000. Soon after the settlement of these strangers new articles of manufacture were introduced, and the admixture of mohair and silk with the wool produced a total change in the quality of the goods. The camlets made to order for the East India Company were annually from 12,000 to 20,000 pieces, until 1833, when the order was transferred to Yorkshire for a cheaper but inferior article. In 1784 the manufacture of cotton was introduced into the city; but the invention of the spinning-jenny, and the facilities possessed by the north, with its coal and iron, for the development of that great power, proved fatal to the progress of cotton manufactures in Norwich. In 1819 a new silk and worsted fabric, called "Norwich crape," was invented, and became so fashionable, that during the Walpole administration (1821) court mourning was ordered entirely to consist of it. Subsequently the chalis superseded this fabric; it was woven in Norwich, but printed in London. The most flourishing period of Norwich manufactures was during the middle of the last century, when fabrics of almost every kind were made. The camlet trade of late has greatly revived, and large quantities are now made for exportation. Fancy goods are also made to a great extent for the American and Australian markets in great variety. Poplins; plain, watered, and figured chalis; cashmeres, tamataves, gauzes, crapes, silks, satins, satinettes, lustres, mousseline de laines, velvets, &c., are all now produced in abundance by the Norwich weavers. The numbers engaged in woollen manufactures at the last census were 973; in silk and woollen goods, 3996; flax and hemp, 304; cotton, 178. There are also extensive establishments for dyeing and finishing the goods manufactured. During the past ten years the manufacture of shoes has been very largely carried on. At this time the number of persons employed in the work amounts to 2722 men and 1241 women, besides those wives of shoemakers who frequently earn a good addition to their income by binding. There are 114 curriers, 26 fellmongers, and 30 tanners in the city. Very large manufactures of oil-cake, starch, and mustard have sprung up of late. The premises of one new establishment of the kind covers three acres of ground. Brushes are now being extensively made in the city; and tobacco is manufactured in large quantities for London and other markets.

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Principal features. The city of Norwich is built partly upon a plain on the banks of the River Wensum, a tributary of the Yare, navigable for barges, and partly on the gentle acclivity of a hill. The ancient boundary walls, of which few fragments remain, inclosed a space of a mile and a half from N. to S., and a mile and a quarter from E. to W. The modern suburbs have, however, long outgrown these limits. Its chief characteristics are its castle, crowning the summit of a curious sugar-loaf hill, of remote but doubtful origin, in the central part of the city; its noble cathedral; its multitude of churches, nearly all built of flint, some very old, but chiefly of the perpendicular period; its quaint guild-hall, a rare specimen of flint studwork; its spacious market-place, and badly-paved, narrow, winding streets, branching off from open spaces or *plains* of frequent occurrence. The unusually large proportion of ground occupied by gardens has obtained for it from very ancient times the title of "The City in an Orchard." The castle, as before stated, is of Norman architecture, occupying the site of an ancient British fortress. The walls of the *keep* exist entire, but the exterior has been so completely renovated as to present quite a modern appearance. The interior, however, preserves its genuine features of antiquity. The space around on the summit of the hill has been inclosed, and very commodious arrangements been made for the accommodation of prisoners, the whole building having been appropriated as a county jail since the reign of Henry III. The castle-hill or meadow beyond the ditch which surrounds the sugar-loaf hill, occupies a large area, and is used as a cattle and sheep market. The fairs are also held there.

Public buildings. The cathedral is one of the finest specimens of Norman architecture existing in the country. The tower is unrivalled for the beauty of its details and proportions. It is

Norwich. not well situated, being closely surrounded by buildings and walled-in gardens, among which may be traced vestiges of the old monastic edifice of which the cathedral formed a part. The transepts and west fronts have been restored, but not thereby improved in beauty. The chief entrance on the west is a deep and vaulted portal of pointed architecture, above which is a noble well-proportioned window, recently filled in with stained glass, the design of which is totally out of character with the tracery of the window itself. The nave within is grand and imposing, divided in length by fourteen semicircular arches of great solidity and depth, supported by massive piers, excepting in two instances, where the piers are replaced by cylindrical columns ornamented with spiral mouldings. The triforium is composed of similar arches. The side aisles below are low, and the vaultings plain. The nave and aisles are 72 feet in width, and 204 feet in length. The roof is elaborately decorated with sculptured bosses. Two of the arches of the south aisle of the nave are perpendicular, the vaulting being of the latest florid style, strangely out of harmony with the simplicity of the Norman style which prevails around. This formed the chapel of Bishop Nix, the last Roman Catholic bishop of the diocese, famous for his persecutions of the Protestants in the reign of Mary. The choir, which is 183 feet in length, extends westward considerably beyond the tower, is of unusual length, and imposing in its effect. On each side of the entrance are the stalls of the dean, archdeacon, and prebendaries, all beautifully carved. The transepts have been thrown open to the choir, much increasing the accommodation for sittings, and improving the general effect. The chancel terminates with an apsis, in recesses of which formerly were the stalls of the bishop and clergy. The decorating of both nave and choir is peculiarly beautiful; the lantern of the tower, which rises upon four semicircular arches, supported by four massive piers, is handsome, but disfigured by painted medallions on the ceiling. A curious speculatory or oriel, for watching the altar at Easter, remains in the north wall of the chancel. There are only two tombs with statues in the cathedral,—one to Bishop Goldwell, a curious specimen of the style of monumental sculpture in the fifteenth century; another, modern, to the memory of Bishop Bathurst, by Chantrey. Mural monuments are plentiful. Sir William Boleyn, great-grandfather of Queen Elizabeth, is buried on the south side of the choir; the founder, Bishop Herbert de Losinga, lies in the centre of the chancel. The cloisters are situated on the south of the nave, and form one of the largest quadrangles in England, being 174 feet in length on each side. They are in excellent preservation, and elaborately-sculptured bosses ornament the vaulted roofs. At the south-west corner are two lavatories. The cloisters were 133 years in progress of building. The church is dedicated to the Holy Trinity. Several chapels still remain about it; only one, however, is fitted up for use—St Luke's, which is used as the parish church. The bishop's palace is a low rambling structure of mixed dates, the most ancient portion being the cellars, which are groined and vaulted. Some ruins exist of an ancient refectory, now overgrown with ivy. The whole place was thoroughly desecrated and spoiled at the period of the Commonwealth. Two of the gates of the Close are fine specimens of the architecture of the thirteenth and fourteenth centuries.

The next public building of importance is St Andrew's Hall, a fine old ecclesiastical structure, originally the nave of the church of the Black Friars' monastery. At the Reformation and suppression of the religious houses, the corporation of the city negotiated the transfer of this handsome edifice to its possession for the sum of L.80. Since that time its nave has served the purposes of a spacious town-hall, and is used for every variety of civil and political meeting, most especially for the triennial musical festivals for which Norwich is so justly celebrated. The chancel has always been preserved for religious worship, having been leased by the corporation to the Dutch congregation, who in their turn grant permission for its use to the chaplain and poor of the workhouse, which stands on the site of other parts of the monastery, the cloisters being converted into kitchens, &c. The hall is of perpendicular architecture, and was built by the famous Sir Thomas Erpingham. The roof is open timber, and supported by two rows of slender and graceful pillars, which divide the nave and aisles. It is now adorned with portraits of civic dignitaries and other paintings, among which are two historical pieces by Martin, a native of the city, and a fine full-length portrait of Lord Nelson. Norwich.

The guildhall, an ancient and curious specimen of flint-work, stands in the north-west corner of the market-place. The assizes for the city are held there, as well as all meetings of the magistrates and council. The council-chamber is a handsome room, fitted up with furniture of the period of Henry VIII., and is an interesting specimen of a court of justice of that period. A glass case incloses a naval trophy in honour of Lord Nelson, being the sword of the Spanish admiral, Xavier Winthuysen, presented by his lordship to the corporation. The original letter accompanying the sword is inclosed in the case.

The market-place is an oblong of very irregular outline. Many gable-ended roofs lingering above the modern shop-fronts, and quaint projecting storeys, give a picturesque and somewhat foreign character to the scene. The market is abundantly supplied with provisions of every kind. Poultry and sausages, the staple product of Norfolk and Norwich, of course abound; and in summer the display of plants and flowers forms a very pretty addition to the view.

Norwich has two large public libraries, in addition to the new free library opened in 1857, which already numbers some thousand volumes, and is much frequented by the class for whom it was designed. A good museum, containing one of the finest collections of birds in the kingdom out of London, occupies the only remaining portion of the ancient palace of the dukes of Norfolk in the city. The museum contains the valuable herbarium of Sir J. E. Smith, the distinguished botanist. It has a spacious corn exchange, where a very extensive business is carried on; and assembly-rooms for miscellaneous purposes. The gaol is a modern structure on the confines of the city. The churches, thirty-six in number, besides the French and Dutch church, are not generally worthy of note, save to the antiquarian. St Peter's Mancroft, the largest, is a handsome structure, measuring 180 feet in length, and 60 in height, with north and south aisles. It has lately been completely restored, and fitted up with open seats. The roof is fine open timber-work, and the organ one of those originally built by Harris. The church contains many curious tombs and monuments. The famous Sir Thomas Browne was buried beneath the chancel of this church. The peal of twelve bells in the tower is said to be unrivalled. The tenor bell weighs 41 cwt. St Andrew's, St Stephen's, and St Michael's Coslany churches are the next in importance. Besides the numerous churches, Norwich has two Roman Catholic chapels, a Jews' synagogue, and between twenty and thirty dissenting places of worship. The city is well supplied with charitable institutions. It has four endowed hospitals for the poor, each possessing very large funds. St Giles, the most important, has an income of nearly L.8000 per annum; while as much as L.10,000 per annum is dispensed in the city through the medium of other charitable institutions. The Norfolk and Norwich Hospital may be classed among the most important of these; it was established in 1772, and contains 105 beds. The number of patients that have been admitted since the opening is 47,072

Norwich ‖ Nostradamus.

in-patients, and 37,531 out-patients. From December 1855 to December 1856 the number was—in, 781; out, 721. A public dispensary, eye infirmary, infirmary for sick children (established by Jenny Lind), a Bethel blind asylum, orphans' homes, and many other charitable institutions exist, and several very rich benevolent societies.

The corporate body consists of 16 aldermen and 48 councilmen. The mayor and sheriff are chosen annually from their number. The city has sent two members to Parliament since Edward I. Pop. (1851) 68,195. (S. S. M.)

NORWICH, a town of the United States of North America, state of Connecticut, at the confluence of the rivers Yantic and Shetucket, which join to form the Thames, 13 miles N. of New London, and 40 E.S.E. of Hartford. It is built on the slope of a hill, and has a fine appearance from the river, the streets running in terraces one behind the other. There are here county buildings, a town-hall, eight or nine churches, several schools, and six banks. The water of the rivers supplies moving power to several manufactories, which produce woollen and cotton stuffs, paper, ropes, leather, pottery, &c. The River Thames is navigable up to this place; and Norwich also communicates with the sea by means of a railway on each side of the river. There is daily steam communication between New York and a point 7 miles below Norwich. Pop. (1850) 10,265; (1853) about 11,500.

NORWOOD, a town of England, in the county of Surrey, 6 miles S. of London. It contains two district churches, one of Grecian and the other of Gothic architecture; Wesleyan, Independent, and Baptist places of worship; several schools; almshouses; and a Roman Catholic convent. Among the places of interest are the noble public cemetery, and a pleasure ground called Beulah Spa, which contains a mineral spring. Pop. 3977.

NORWOOD, RICHARD. See DISSERTATION IV., § 4.

NOSSI-BE, or NOS-BEH, an island in the Indian Ocean, in front of the Bay of Passandava, on the N.W. coast of Madagascar; S. Lat. 13. 20., E. Long. 48. 20. It is irregular in outline and surface, and evidently of volcanic formation. The highest summit, which is near the southern extremity, is about 1700 feet above the sea, and is covered with fine timber to the top. The area of the island is about 580 square miles. The land near the sea is well cultivated, and produces rice, maize, potatoes, &c., more than enough for the inhabitants. At several places on the coast excellent anchorage may be obtained. Nossi-Be belongs to the French, being a dependency of the Island of Bourbon. Pop. (1851) 15,178.

NOSTRADAMUS, MICHEL DE, or NOTRE-DAME, a celebrated physician and astrologer, was descended of a noble Provençal family, and born on the 14th of December 1503, at St Remy, in the diocese of Avignon. He studied humanity and philosophy at the college of Avignon, and physic at Montpellier. On the outbreak of the plague in 1525 he set out towards Toulouse, and passed on till he reached Bordeaux. After spending five years on the journey, treating all the patients that came in his way, he returned to Montpellier, and was created doctor of his faculty in 1529. At Agen he contracted an acquaintance with Julius Cæsar Scaliger, which induced him to make some stay in that town. On his return to Provence, he established himself first at Marseilles, and afterwards at Salon, where he became a recluse, and employed his leisure in study. In 1546 he rendered essential service by his medical skill to the inhabitants of Aix, then suffering from a severe visitation of the plague. He had for a long time occasionally followed the trade of a conjurer, and now he began to think himself inspired, nay, miraculously illuminated with a prospect into futurity. As often as he fancied these illuminations discovered to him any future event, he entered it in writing, in enigmatical prose sentences; but revising them afterwards, he thought the sentences would appear more respectable, and would savour more of a prophetic spirit, if they were expressed in verse. This opinion determined him to throw them all into quatrains, and he afterwards ranged them into *Centuries*. When this was done, he hesitated about making them public, till reflecting that the time of many events which he had foretold was very near at hand, he determined to print them. This he did with a dedication addressed to his son Cæsar, an infant only some months old, in the form of a letter or preface, dated the 1st of March 1555. This edition, which includes seven *Centuries*, was printed by Rigault at Lyons.

Notary.

Henri II., and his mother Catherine of Medicis, having resolved to see the prophet, he received orders to repair to Paris. He was very graciously received at court; and he returned to Salon loaded with honours and presents. Animated with his success, he augmented his work from three hundred quatrains to a complete milliad, and published it in 1558, with a dedication to the king. That prince having died the next year of a wound which he received at a tournament, the book of the prophet was immediately consulted; and in the 35th quatrain of the first century this unfortunate event was, strange to say, found predicted.

So remarkable a prophecy added greatly to his fame, and he was shortly afterwards honoured with a visit from Emanuel, Duke of Savoy, and the Princess Margaret of France, his consort. From this time Nostradamus found himself overburdened with visitors, and his fame daily increased. Charles IX. presented him with a purse of two hundred crowns, together with a brevet, constituting him his physician in ordinary. But the prophet enjoyed these honours only for the space of sixteen months, having died at Salon on the 2d of July 1566. Besides his *Centuries*, we have the following compositions of Nostradamus:—A treatise *de Fardemens et de Senteurs*, 1552; a Book of singular Receipts, *pour Entretenir la Santé du Corps*, 1556; a piece *des Confitures*, 1557; and a French translation of the Latin of Galen's *Paraphrase*, 1552. In addition to various *Prophecies*, some of which were translated into English during his own time, he published the *Almanac of Nostradmaus* in 1559. The eleventh and twelfth *Centuries* of his quatrains were published after his death. It is to these productions that the following pungent distich was applied by Jodelle:—

> Nostra damus cum falsa damus, nam fallere nostrum est,
> Et cum falsa damus, nil nisi Nostra damus.

NOTARY, in its original signification, was applied to a person (*notarius*) employed to take notes (*notæ*) of trials and other judicial proceedings in the Roman courts. These *notarii* represented in some measure our modern reporters, and, like them, employed symbols of abbreviation, or a species of short-hand, to facilitate the reporting of a speaker's words. This appears from various passages in classical and ancient writers, such as Manlius and Martial. The notarii were generally slaves; and, in addition to their ordinary duties, not unfrequently took down a man's will in writing, and were sometimes called upon to attend the prefects in the capacity of transcribers, and attest the acts of spiritual dignities when the empire became Christian. In the fourth century the notarii received the name of *exceptores*, and the functionaries corresponding most nearly to the modern notaries were termed *tabelliones*. The business of the latter was to draw up contracts, wills, and other legal instruments. It is impossible to determine when notaries were first known in England. As early as the time of Edward the Confessor we read of charters being executed by notaries for the royal chancellor. The power of admitting notaries to practise seems to have been vested in the Archbishop of Canterbury by the 25 Hen. VIII., c. 21, sec. 4. The term of a notary's apprenticeship, and the manner of his admission to practise, are regulated by the act 41 Geo. III., c.

Notation ‖ Noto.

79, and amended by the 3 and 4 Will. IV., c. 70, and 6 and 7 Vict., c. 90. The recent statutes, 20 and 21 Vict., cc. 77, 85, for the abolition of the ecclesiastical courts, do not affect the notaries. As appears from countless allusions in our literature, it was customary in former times for notaries to make all kinds of legal instruments. Their occupation is now limited to the attestation of contracts and writings of a mercantile kind, to their authentication in a foreign country, to the protestation of bills of exchange, &c. They also receive and take the affidavits of masters and mariners of ships. The notaries have to pay an annual certificate duty, like attorneys, solicitors, and proctors; and in the stamp act, 44 Geo. 3, c. 98, prohibiting persons not duly qualified from preparing deeds relating to real or personal estate, notaries, as well as attorneys, &c., are excepted, subject to their taking out their annual certificates.

In *Scotland*, before the reign of James III., papal and imperial notaries practised until the third Parliament of that king, held at Edinburgh on 29th November 1469, when an act was passed declaring that notaries should be made by the king. It would appear, however, that for some time afterwards there were in Scotland two kinds of notaries, clerical and legal,—the instruments taken by the latter bearing faith in civil matters. In 1551 an act was passed directing sheriffs to bring or send both kinds of notaries to the lords of Session to be examined; and in a subsequent statute, passed in 1555, it was ordained that no notary, "by whatsoever power he be created," should use the office "except he first present himself to the said lords, showing his creation, and be admitted by them thereto." It does not appear that this statute vested the right of making notaries in the Court of Session; but in 1563 it was by law declared that no person should take on him the office, under the pain of death, unless created by the sovereign's special letters, and thereafter examined and admitted by the lords of Session. Since then the Court of Session have in Scotland exercised full and exclusive authority on the admission of notaries in all legal matters, spiritual and temporal. It is the privilege of notaries to expede the instruments by which a proprietor is infeft or feudally vested in land, to protest bills, to authenticate copies of writings, and generally to do what is usually done by the notary in England.

NOTATION, the method of expressing numbers or quantities by signs or characters appropriated for that purpose. (See ARITHMETIC and ALGEBRA.)

NOTES, in music, are characters used in writing or printing, to mark the pitch and the duration of the sounds of any musical composition. These characters or signs of notation have varied much at different times. Many alterations of those now generally received have been proposed, but not adopted. *Numerical* and *literal* methods of expressing musical sounds have been repeatedly proposed; but it seems that these are even more complicated than the method in common use. A musical shorthand, constructed of alphabetical letters, was proposed in 1805 in France, but rejected; although in numerous cases of simple melody and harmony it might be very useful in saving space to publishers of books. (As to the notation of music in ancient and modern times, see Padre Martini, Hawkins, and Burney, and especially Mersenne and Mace regarding the *entablature* of some musical instruments now disused.) (G. F. G.)

NOTO, a town of Sicily, capital of a province of the same name, stands on a hill near the left bank of the River Noto, not far from its mouth, and 14 miles S.W. of Syracuse. It is well built, and has regular streets and spacious squares. There are several churches and convents; a college; a museum, with a large collection of Greek, Roman, and Moorish coins; council-house; hospital, &c. Some trade is carried on in corn, wine, and oil. About 4 miles to the N.W. are the remains of the ancient Netum, consisting principally of an amphitheatre and a gymnasium. Pop. 11,065.

Nottingham.

NOTTINGHAM, a large market-town of England, the capital of the county of the same name, in the centre of England. Since the time of Henry VI. the town has been itself a county, with its own recorder and sheriff. It is a place of great antiquity, deriving its name from the Saxon word *Snottingaham*, which is descriptive of its position as a retreat in rocks, since there were formerly many, and are still a few, caverns, cut in the soft rock on which its castle was built. It is by some antiquaries asserted that it was once a Roman station; but that is a subject of controversy. The earliest records notice some incursions of the Danes about 866; but they appear to have received a check from the town, and a defeat near it from King Alfred, who afterwards made it the winter-quarters of his army. William the Conqueror erected a castle, and constructed fortifications so strong as to render the place impregnable against any of the methods of attack which were then known. King Richard Cœur de Lion assembled a Parliament in this place previously to his departure for the Holy Land, and another soon after his return from Palestine. It was from Nottingham that Richard III. marched forth to his fatal battle of Bosworth Field. Here Charles I. erected his royal standard at the commencement of the civil war, at a spot now included in the General Hospital gardens. The castle of Nottingham, defended by the royalists, was besieged by the parliamentary forces under the command of Colonel Hutchinson, to whom, after a brave defence, it at length surrendered. The particulars of the siege are related in a most interesting manner by the wife of that officer. When Cromwell had attained supreme power, he ordered the fortifications to be destroyed, and the castle to be dismantled. Early in the present century this town and neighbourhood were distinguished by the riotous disposition of the lower orders. This was especially the case between the years 1811 and 1814, when the Luddites, as they were termed, were excited to destroy much of that machinery by the aid of which the town subsequently attained to its present high degree of affluence. These disturbances were quelled by the power of the law, and some wholesome severities; but a portion of the trade was transferred to distant and more tranquil districts. During the excitement respecting parliamentary reform a very violent spirit was manifested, which led to the destruction of a silk-mill in the neighbourhood, many outrages upon private houses, and the burning of the castle belonging to the Duke of Newcastle on October 10, 1831. These disturbances led to a few exemplary punishments and some heavy burdens on the town, to indemnify those whose property had suffered by the riots.

Nottingham is finely situated upon the side of a hill overlooking the valley of the Trent, and near to the south-western extremity of what was formerly the forest of Sherwood, once famous as the resort of the celebrated Robin Hood, but now a well-cultivated district. The environs of the town are picturesque and beautiful. It is surrounded, except towards the Trent, by eminences which command extensive views of the neighbourhood and of adjoining counties. Clifton Grove and the village of Wilford, celebrated by Kirke White, together with Wollaton Hall, the seat of Lord Middleton, and Belvoir Castle (distant 19 miles), are marked features in the landscape.

Immediately contiguous to the town, on its western side, is the Park, an appanage of the castle, and originally a grant from the crown. It was purchased of Francis, Earl of Rutland, by William Cavendish, first Duke of Newcastle, who commenced the present building in 1674, in the eighty-third year of his age. The park contains about 120 acres, and is remarkable for its undulatory surface. The boundary next the town is marked by a range of hills upwards of 100

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feet high. These terminate abruptly on the south-west with a magnificent precipice, 130 feet high, upon which the castle stands. The whole is of the New Red Sandstone formation, and readily yields to the stroke of the quarryman. It is to the facilities thus afforded by nature that the numerous caverns and rock habitations, for which Nottingham and the Park are so famous, owe their origin. After the estate came into the possession of the present duke, a lofty tunnel was cut through one of the sandstone hills above named, constituting the principal carriage approach from the town to the valley of the Park. The ground is laid out for villa residences, and terraces and drives are formed; the valley being set apart for pleasure-grounds and ornamental planting. The landscape is rarely equalled in beauty, and affords a sudden and magical transition from town to country. Of this the merchants and principal inhabitants have availed themselves, by erecting residences of a costly, and for the most part elegant and tasteful character. The Park is bounded on the south by the River Leen, or rather the artificial watercourse said to be formed by William Peverill, the first grantee of the castle, in the time of William the Conqueror. The original bed of the river as it ran into the Trent may be now traced at the point at which it was diverted.

Some of the old streets are narrow, but in the great extension of the town of late years some new and spacious avenues have been built, and much improvement has been judiciously effected. The market-place is one of the finest in England. It is spacious, occupying an area of 27,515 square yards, or rather more than five acres and a half. It is well paved, and admirably adapted for the purpose of the two weekly markets held in it on Wednesday and Saturday, the last of which is the principal one. At the east of the market-place stands the Exchange Hall, which is a noble-looking building. The pediment is crowned with a well-proportioned pedestal, on which stands the figure of Justice. On the pediment are the town arms; and underneath it, with a clock intervening, is a handsome Venetian window, ornamented with two elegant Ionic columns, which lights the spacious room within. That apartment, when the temporary doors which divide it are thrown open, is 123 feet long, 30 wide, and 30 high, with an arched ceiling. It is used for public dinners, at which more than 400 persons can be commodiously seated, and also for public meetings. This room was nearly destroyed by an accidental fire in 1836, but has been restored and further beautified. One part of the building is appropriated to magisterial business, and another is occupied as a police-office, and for the residence of the mayor's serjeant-at-mace. Underneath the Exchange there are a few shops in front, but the principal part of the ground-floor is appropriated to shambles. In another part of the market-place is the Subscription Library, containing more than 13,500 volumes, many of them of great value. With this is incorporated the Standfast Library, consisting of works chiefly classical and theological; making a total of nearly 15,000 volumes. There are also maps, and portraits of eminent individuals connected with the town, amongst whom are Colonel Hutchinson, Lord Byron, Sir Richard Arkwright, Kirke White, and others.

The other civic buildings are the county jail and hall, a commodious but not elegant structure; the house of correction and town jail, standing on the site of a convent of the hospitallers of St John of Jerusalem; the town-hall, where the borough assizes and sessions, and the mayor's and sheriff's courts are held; the post-office, occupying a very commanding situation; and the free grammar school, in which 80 boys are educated—40 in the classical, and 40 in the English department.

The edifices for religious worship are in about the same proportion to the number of the inhabitants as is seen in other places which have increased with similar rapidity. St Mary's is usually denominated the mother church of the town, from its priority of erection. It resembles a cathedral more than a parish church in its extent, its architecture, and its decorations, and is the most striking object in the place when viewed from what is called the High Pavement. It stands on an elevated spot, and is said to be nearly 70 feet above the level of the meadows near the town. The date of the erection is unknown, but is said to have been in the fifteenth century. It is in the form of a cross, and has a handsome square tower, in which there is a musical peal of ten bells. The length of the structure in the inside is 216 feet, the breadth at the transept 97, at the west end or principal entrance 67, and in the chancel 29 feet. The height of the tower is 126 feet, and that of the side aisles 60 feet. The porch on the south side is a very ancient and elaborate piece of workmanship, which tradition has assigned to the neighbouring priory of Lenton as its original site. In the north transept there is an excellent organ of great power. There are in this church many monumental inscriptions on tombs of the family of the Earls of Clare, and one of an Earl of Meath, and the mausoleum of the family of the Wrights. In the year 1848 the building, having undergone extensive repairs and numerous alterations, with a view to carrying out its original design, was re-opened for public worship. The cost, upwards of L.9000, was defrayed by a subscription.

Besides the mother church, there are provided for the adherents of the established worship the following edifices:—St Peter's, St Nicholas', St James's, St Paul's, Trinity, St John Baptist's, St Matthew's, and St Mark's. The Roman Catholics possess a cathedral dedicated to St Barnabas, and erected in 1844 at a cost of L.20,000. The Nonconformists have numerous places of worship, some of them large and costly. Wesley and Halifax Place chapels, belonging to the Methodists, will accommodate each 1800 persons, and the former is stated to have cost L.10,000. Other descriptions of Methodists have 5 places of worship; the Baptists of various orders 7; the Independents 4; the Unitarians, Quakers, Irvingites, and numerous other sects, 1 each. In 1851 the total number of places of worship was reported as 37, of which 8 belonged to the Church of England, and 29 to other religious bodies. The largest reported attendance (on Sunday, March 31) in that year was, at the several churches, 5570, and at the other places of worship 11,284.

The charitable institutions depending on endowed foundations or on voluntary contributions are numerous. The Blue-Coat School clothes and educates about 50 boys and 20 girls. The General Hospital, built in 1781, possesses about two acres of land, given partly by the Duke of Newcastle and partly by the corporation. It is supported chiefly by subscriptions, and usually contains about 140 patients; whilst between 1100 and 1200 are out-patients receiving medical advice and assistance. The Dispensary, established in 1831, has on an average 350 patients. The General Lunatic Asylum is a modern and spacious brick building, erected in 1810, at an expense of nearly L.20,000. There are extensive courts, gardens, and places for recreation; and the whole economy of the place is well contrived for the recovery of the inmates. The foundation of a second asylum for patients of the middle class was laid by the Duke of Newcastle, October 30, 1857. Labray's and Lambley's Hospitals are small asylums for aged widows; and Collins' Hospital is a splendid charity, founded by one of the Smith family of the town, of which Lord Carrington is the present head. It consists of twenty-four small but convenient dwellings for as many poor widows, each of whom receives four shillings weekly, and two tons and a half of coal every year. From the same endowment Carrington Street Hospital, which accommodates 20 inmates, was built between the years 1831 and 1834. Plumptre Hospital, founded by a family of that name (since transplanted into

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Kent) in the year 1392, but twice repaired since,—viz., in 1650 and 1751,—has been rebuilt under an act of Parliament passed in 1823. Thirteen aged widows are provided with comfortable dwellings within the house, and allowed six shillings weekly, whilst thirty others, called out-pensioners, receive ten pounds a year. Willoughby's Hospital contains nineteen tenements, the inhabitants of which receive a small pension. Wooley's Alms are dwellings for six poor persons; and Bilby's Almshouses for eight persons, who have each a loaf weekly, and two tons of coal at Christmas. Warser Gate Hospital gives apartments to six, and Hanley's to twelve poor persons. Other almshouses exist; so that in the year 1844 the number of persons thus provided for was 180. In 1852 Mr George Gill erected six additional tenements for decayed workmen.

Among the public edifices that deserve notice may be mentioned the barracks, built in 1792, a plain building, with apartments for officers and privates, and suitable stabling for three troops of horse. At the close of 1857 the government resolved on erecting new barracks on a different site, granted by the corporation. There is an assembly-room, as well as a theatre of moderate dimensions, and the usual provision of gas and water works, &c. Among the comparatively recent buildings of a public character are a savings-bank; a mechanic's institution, with a hall capable of accommodating 1000 persons, a library of 6000 volumes, a museum of natural history, reading-rooms, &c.; the Artizan's Library, containing 2000 volumes; the People's College, founded by Mr George Gill in 1847, intended to bring the higher advantages of education within common reach; a large and handsome asylum for the blind; a ragged school; a female refuge; and baths and wash-houses. Two of the older mansions of the town are now occupied, the one as a government school of design, and the other as a people's hall, a gift to the working-classes by a benefactor whom we have already named, Mr George Gill. To these must be added a large and handsome building, erected in 1853 as a corn market, and now used as a general exchange and news-room. To this is attached a telegraph office.

The most important event in the modern history of Nottingham was the passing, on June 30, 1845, of an act for the inclosure of about 1300 acres of pasture land, by which the town was nearly encircled, and which was subject to rights of common. Surrounded by this belt of open country, the town had been hemmed in upon a space of 265 acres, and was one of the most densely peopled in the kingdom,—an immense surplus both of trade and population, properly identificd with Nottingham, being located in large manufacturing villages in the immediate vicinity. The effects of the act are strikingly apparent. Many hundreds of houses, with numerous factories, now spread over the recently-inclosed space. It is traversed by public and private roads of more than 18 miles in length. Upwards of 50 acres are laid out, for the purposes of public recreation, in a cricket-ground, ornamental walks, and an arboretum of about 20 acres, to which there is free admission. An extensive race-ground is included in the space reserved for public accommodation. The inclosure act also provided for the appropriation of 8 acres for the purposes of interment. Of these, four, designed for the use of dissenters, were added to the general cemetery, establishd in 1837, and now comprising 18 acres; and the remainder are incorporated with a recently formed Church of England cemetery, containing in all 13 acres.

The change in the town itself is as great as that which marks its immediate vicinity. Factories and warehouses have sprung up with a rapidity of which scarcely any other town presents an example. Almost all the leading merchants and manufacturers have enlarged or rebuilt the places in which they carry on their business; so that Nottingham appears like a place which has suddenly become the seat of some new and very flourishing trade. The old warehouses, &c., were of the plainest character, and utterly destitute of architectural pretensions. The reverse may be said of the new. Under the direction of Mr Hine and other able architects, the town has now been ornamented with a large number of commercial buildings, which for their architectural character will bear comparison with the higher class of civic edifices to be found elsewhere.

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The population of Nottingham amounted in 1811 to 34,253; in 1831 it was 50,680; and in 1841, 53,091. It had grown in 1851 to 58,529, exclusive of the suburbs of Sneinton and Radford, which are now strictly incorporated with Nottingham, and constitute one town. Of these, the former contained at the last census 8840 inhabitants, and the latter 12,637; making a total of 80,006. To these ought perhaps to be added the immediately contiguous parish of Lenton, having a population of 5589. On this estimate, the population of Nottingham, taking into account its rapid increase during the last few years, cannot fall far short of 100,000. The villages within 4 miles, and most of them, strictly speaking, dependencies of the town, contain an additional population of 30,000.

The Trent is navigable up to the town; and the various canals which branch from that river afford the means of communication with every part of the kingdom. There are two distinct lines of railway connecting Nottingham with the metropolis, as well as with the north, besides lines running to Derby, Newark, Lincoln, Mansfield, Ilkeston, and other places.

We are enabled, on the authority of W. Felkin, Esq., F.L.S., to present the following account of the two principal branches of the trade of this important town:—

Machine-wrought lace trade of Nottingham in 1857.

The surprising invention of the stocking-frame by Lee has issued in one of the most interesting chapters in the history of mechanical invention and manufacturing industry. It was upon this machine that, about a century ago, a coarse imitation of cotton lace was first produced. The fabric was all weft from one continuous thread. A beautiful adaptation of the machinery enabled a fine silk net (point lace) to be made, employing for many years 1500 frames in Nottingham and its vicinity. This fabrication has long since died out. Then the machine was so arranged as that the material should be used altogether as warp. This very ingenious machine is still usefully and extensively employed. Mr John Heathcoat, then a working-frame smith in Nottingham, invented the bobbin-net machine, and patented it in 1809. His first machines were from 18 to 36 inches in width. A woman making lace on a pillow may produce three to five meshes or interstices in a minute. The first machine produced 1000 meshes per minute. A square yard of the produce was sold for L.5. This machine, as originally constructed, though displaying wonderful mechanical skill, was a complicated one. During the whole of the intervening time incessant and remarkable ingenuity has been shown in simplifying and improving the machine. It is now made 180 to 200 inches in width; and plain net of like quality to that first made is sold currently at 6d. for the square yard. A man turns off with ease 40,000 meshes per minute from this "mechanical pillow," as the bobbin-net machine was originally called by its talented inventor. Luddites having broken the patentee's machinery at Loughborough, he established himself at Tiverton, where he now employs 300 machines. He has represented that borough in Parliament since 1831. There are also about 100 machines at Barnstaple, 250 at Chard, 100 in the Isle of Wight, and 300 in Derbyshire. There are 2550 bobbin-net and 800 warp machines at work in Nottingham and its vicinity. Excepting less than one-tenth of the production, the whole of the English bobbin-net machinery is employed for the Nottingham lace trade. The capital in this machinery amounts to L.1,500,000, independently of that employed in the construction of doubling and throwing raw materials used in this branch of business. The number of persons wholly or in part engaged in it is 135,000, or more—as smiths, machine hands, menders, warehouse men and women, finishers, embroiderers, &c. Wages may be stated at,—men 20s. to L.5; youths, of both sexes, 8s. to 20s.; children, 3s. to 8s. per week. The whole machinery, or nearly so, is worked by steam or water power, where employed on plain or common fancy goods. The Jacquard apparatus has been applied at great cost, but with perfect success, to about 2500 of the machines, making every class of bobbin-net and warp goods, up to the most expensive and close imitation of pillow articles. The statistics for 1857 may be stated, with pretty close approximation to truth, as follows:—

Nottingham.

3600 bobbin-net, and 800 warp lace machines used up 9,600,000 lb. weight of raw cotton wool, at an imported cost of L.712,000, to which was added L.2,318,000 wages and profits; making a total return of L.3,030,000: and raw silk, 450,000 lb., at a cost of L.503,000, to which was added wages and profits L.1,247,000—total return in silk lace goods, L.1,750,000. There were therefore materials used costing L.1,215,000, to which were added wages and profits L.3,565,000; making the entire return L.4,780,000, of which L.4,300,000 passed through the warehouses of Nottingham. About two-fifths of the amount is believed to be exported. During the first twenty years after the bobbin-net machine was invented, pillow lace was very adversely affected by it. Since then the cheaper machine lace has led the way to a larger consumption of pillow lace goods, and at better wages and prices than for ages before.

Hosiery trade of Nottingham in 1857.

The machinery invented in 1589 by the Rev. W. Lee, at Woodborough, in the county of Nottingham, for the manufacture of hosiery, was the result of extraordinary mechanical genius. After his death it was chiefly transferred to and around London; but a century ago it had become concentrated in the three midland counties. In order to bring before the public the sufferings of the people then engaged in this branch of trade, Mr William Felkin of Nottingham caused a minute census of the machinery to be taken in 1844. This statement included the frames, hands employed, classes of work produced, materials used, throughout 230 parishes in the counties of Leicester, Derby, and Nottingham, where stocking-frames were to be found, as well as those which were in other parts of the three kingdoms. In Leicestershire there were 6933 employed upon cotton, 9875 woollen, 168 silk, 1582 mixed, and 2303 not at work; total, 20,861. In Derbyshire, 4380 cotton, 171 mixed, 1454 silk, and 792 not at work; total, 6797. In Nottinghamshire, 12,440 cotton, 2094 silk, 299 mixed, 46 woollen, and 1503 not at work; total, 16,382. In other parts of England, 1572 frames; in Scotland, 2605; in Ireland, 265. Total stocking-looms in the three kingdoms, 48,482.

These machines had been worked in small shops, or the houses of work-people. The rates of wages in 1844, and for forty years previously, had been depressed to the lowest living point, it being all hand employment. Since that year there has been a gradual but most important improvement throughout the whole trade. The demand for goods has gone somewhat beyond the supply of labour; the rates of wages have advanced 50 to 100 per cent., according to classes of goods made; all the available machinery has been employed, though the former excessive hours of work have been shortened; and the former wretchedness of the people has disappeared. During the last ten years about 1300 sets of power rotary round frames have been constructed, about 800 of which are in Nottingham, and 500 in the two adjoining counties. Several hundreds of wide frames have been placed in factories, and adapted to rotary steam-power. Out of the total number of stocking-looms (about 50,000), there are now at least 17,250 engaged in the trade of Nottinghamshire, giving employment in making, stitching, sewing, finishing, &c., to about 40,000 men, women, and children, at from 30s. to 2s. 6d. a week. Of the production of Nottingham hosiery, about one-third, it is believed, has been of late exported. The value of Nottingham hose-frames is estimated at L.310,000.

The kind and quantity of materials used, and value of hosiery goods produced in 1857, bear no comparison with 1844, or any former period. One workman in a hand-frame may produce one dozen cotton hose, weighing 2 lb. on an average, in a week; one set of round frames, managed by one man, will turn off easily 200 dozen, each of 1½ lb. weight (using 300 lb. of cotton per set) in a week. Such hose are selling, when prepared for market, at 2s. 6d. per dozen. This cheap hosiery has forced its way where stockings were unknown; and in both home and foreign markets an increased demand for every class of English hosiery has marked the late epochs of enlarged manufacturing prosperity.

The following is an approximate estimate of the production of hosiery in the Nottingham trade of the year 1857:—

Material.	Consumpt of raw material.	Cost in Import.	Wages and Profits.	Total Return.
	Lbs.	L.	L.	L.
Raw cotton wool..	9,000,000	338,000	987,000	1,325,000
Mixed wool.....	2,600,000	107,000	333,000	440,000
Raw silk.....	100,000	100,000	235,000	335,000
Total.....	.....	545,000	1,555,000	2,100,000

Nottingham has been celebrated for its ale, the qualities of which have been the theme of song. It is still good, and very potent. Its excellence has been attributed by some to the good quality of the barley grown in the neighbourhood, by others to the purity of the water, and by many to the excellent cellars scooped out of the rock, with which most of the good houses are furnished.

Nottinghamshire.

This town returns two members to the House of Commons. The freemen, who were formerly the sole electors, are still numerous, but are exceeded in number by the ten-pound voters.

By the municipal corporation reform law passed in 1835, the town is to continue a corporation, is divided into seven wards, and has a mayor, fourteen aldermen, and forty-two councillors, with twelve justices of the peace appointed by the crown. (S. M—LL.)

NOTTINGHAMSHIRE, an inland county of England, bounded on the N. by Yorkshire and a part of Lincolnshire, on the E. by Lincolnshire, on the S. by Leicestershire, and on the W. by Derbyshire. It is of an oval figure, with its narrowest end towards the north. Its greatest length is about 50 miles, and its greatest breadth 27. Its circumference is estimated at 140 miles. The number of square miles is 822, or 526,076 acres.

The county is divided into six hundreds, or, as they are usually denominated, wapentakes; three of which are to the north and three to the south of the River Trent. It contains nine market-towns, and 207 parishes. The annual value of the real property assessed to the property and income tax for the year ending 5th April 1851 was L.1,198,843. The number of inhabitants amounted in 1801 to 140,350; in 1811 to 162,000; in 1821 to 186,873; in 1831 to 225,400; in 1841 to 249,910; and in 1851 to 270,427.

The number of inhabited houses in 1851 was 55,019. We are not enabled to state the exact proportions of the several classes engaged at that date in trade, agriculture, &c. According to the census of 1851, the county contains 231 public day-schools, 58 of which are supported by endowments, and 136 by the voluntary subscriptions of members of the Established Church. The total number of scholars in public and private day-schools is 31,178. The number of Sunday schools is 428, of which 183 belong to the Established Church, and 245 to other religious communions. The total number of scholars in the former is stated to be 17,785, and in the latter 26,153. The places of worship belonging to the Church of England are returned as being 248, and those belonging to other religious bodies as 382, of which the large proportion of 273 is assigned to the Wesleyan Methodists. The number of sittings is reported as 160,234, of which the Established Church furnishes 76,960.

The towns and villages containing more than 2000 inhabitants, and the numbers in each, were in 1851:—

Nottingham	58,529	Southwell	3,516
Newark	11,330	Beeston	3,016
Mansfield	10,627	Hucknal-Torkard	2,970
Basford (parish)	10,093	Retford	2,943
Worksop	7,215	Clarborough	2,504
Sutton in Ashfield	6,542	Kirby in Ashfield	2,363
Lenton (parish)	5,589	Carlton	2,329
Greasley (parish)	5,284	Ruddington	2,181
Arnold	4,704	Bingham	2,054
Bulwell	3,786		

The face of the country is generally level, with moderate undulations; and its beauties are of a mild description, somewhat picturesque in the vicinity of Sherwood Forest, but displaying neither the striking features of the adjoining county of Derby on its western side, nor the flat insipidity of the plains of Lincolnshire on its eastern side. From its position between these two descriptions of country, and from its moderate elevation, it enjoys a milder climate than either, partaking neither of the cold air of the one nor the moist atmosphere of the other. The mean temperature of the county town is said to be only 1½° below that of London, or 49°·73. The dryness of the climate is favourable to early vegetation, and is supposed to be the cause of the seed-time and harvest in Nottinghamshire commencing at the same period as in the more southern counties.

Nottinghamshire.

The soil of this county is very various. On the borders of Derbyshire there is a stripe of land with coal and limestone, partly in wood, but mostly under arable culture. Parallel to it is a broader tract, including Sherwood Forest, the soil of which is chiefly sandy and gravelly; but though naturally sterile, it has in some degree been brought into a productive state by the extensive cultivation of turnips, and the maintenance of considerable flocks of sheep. The tract which adjoins is a clayey soil, extending to the banks of the River Trent. It is chiefly arable land, but varied with woods and meadows, and highly productive of wheat, oats, beans, and, in some parts, of hops. The lands on the banks of the Trent are very fertile, being mostly devoted to pasture, on which many oxen are fattened; and some of the dairies are extensive. The arable land of this district is celebrated both for the quantity and the quality of the oats which it produces. The beautiful vale of Belvoir, in the south-easternmost part of the county, enjoys some of the best soils, both for pasture and arable husbandry, of any part of this island. The farms are in general small, and commonly held by tenants at will, the rents taken from whom are generally moderate; and a very great proportion of the land is free from the burden of the tithes. The spirit of agricultural improvement has not proceeded so far as in many other counties, though it has made considerable progress of late years. Neither the breeds of cows and sheep nor the modes of cultivation differ so much from those of the adjoining counties as to deserve any especial notice.

There are no mines except those of coal, which are exclusively confined to a narrow district bordering on Derbyshire; the coal is of good quality, very abundant, and, by means of railways and internal navigation, diffused throughout the whole county. Excellent stone for building is raised in many parts, some of which has the peculiarly valuable quality of hardening by exposure to the weather. Many parts of the county abound in veins of gypsum. In the parish of Gotham it is found in strata of the thickness of 3 feet. At Beaconhill, near Newark, there are large quarries of this substance. Although it has been much praised as a manure, the trials of it that have been made in its vicinity have not been attended with such beneficial results as to induce the continued use of it for that purpose. It should only be used in moderate quantity, and on stiff soils.

The forest of Sherwood, formerly celebrated as the scene of the exploits of Robin Hood, whose deeds amused our nursery days, is mostly an open heathy plain, bordered with recent plantations, and upon which the plough has made very extensive encroachments. The boundaries of the forest are extensive, it being 25 miles in length, and from 7 to 9 in breadth; but a great portion of it has become the property of private individuals, and is inclosed in farms and parks; in the latter of which is to be found the deer with which this forest was once most abundantly stocked. The trees of most ancient date are those on the estates of the Duke of Newcastle and Lord Manvers.

Nottinghamshire is, for its population, one of the greatest manufacturing counties. (For information on this subject the reader is referred to the concluding part of the article NOTTINGHAM.) The spinning of cotton-yarn, from its natural connection with the trade of the district, has been introduced and very widely extended; and the establishments at Nottingham, at Pleasley Works, near Mansfield, and several other places, are upon an extensive scale. There are also some large manufactories for silk-throwing and for spinning worsted yarn. Malting and brewing are carried on to a considerable extent; and the beer of Nottingham and of Newark rivals that of Burton-upon-Trent. There are potteries at Sutton-in-Ashfield; starch is made at Lenton; and sailcloth and candlewick at Retford.

The foreign trade of this county is mostly conducted by the mercantile houses of London and Liverpool; but some of the larger manufacturers export their own goods both to the continent of Europe and to the more distant parts of the world.

Nottinghamshire.

The River Trent, the fourth in magnitude of the English streams, passes across the county, and is navigable for barges throughout the whole of it; but its deficiencies of water and its shoals are such great impediments that a canal by the side of it, 10 miles in length, is found of great use to the intercourse. The other rivers are not navigable, but are beneficial for the purposes of irrigation. They are the Erewash, the Soar, the Maun, the Meden, the Wollen, the Worksop, the Idle, the Leen, and the Dover or Dare. These all discharge their waters into the Trent. The canals are—the Nottingham, the Grantham, the Idle, and the Chesterfield. The last of these is about 40 miles in length; the others about 10 each. By means of these and the Trent, the intercourse by internal navigation is extended to almost every district of the county. In addition to this means of communication, all the principal towns, and most of the more populous villages, are now embraced in the railway system.

The titles derived from this county are those of Marquis of Granby, Earl of Mansfield, Viscount Newark, and Barons Pierrepoint and Carrington. For election purposes, the county has been divided into two districts, the northern and the southern. Each of them returns two members. The election for the northern division is held at Mansfield, and the polling-places are, that town, East Retford, and Nottingham. The election for the southern division is held at Newark, and the other polling-places are Bingham and Southwell. The three boroughs, Nottingham, Newark, and Retford, return each two members, as before the passing of the Reform Bill. The whole of the county is in the diocese of Lincoln, to which it was transferred from that of York at the recommendation of the ecclesiastical commissioners in 1836. It is on the midland circuit of the judges.

The remains of Roman and Norman antiquities are numerous. Amongst the former are the camps at Barton Hill, at Combes Farm, at Gringley, at Hexgrave, and at Wenney Hill, and a Roman villa near Mansfield. Among the latter are the Castle of Newark; the abbeys of Newstead, Rufford, and Welbeck; the priories of Mattersey and Worksop; and the churches of Bingham, Blythe, Southwell, and Balderton.

Among the distinguished natives of this county have been Archbishop Cranmer, Dr Erasmus Darwin, Sir Martin Frobisher, Denzil Lord Holles, Ireton, the son-in-law of Cromwell, Lady Mary Wortley Montague, Paul Sandby, Archbishop Secker, Gilbert Wakefield, Bishop Warburton, and Henry Kirke White.

The seats of noblemen and gentlemen of the first class are as numerous as in any county of England. Among the most remarkable are the following, viz.:—Annesley Hall, John Musters, Esq.; Babworth Hall, H. B. Simpson, Esq.; Bramcote Hall, J. S. Sherwin, Esq.; Bunny Park, G. A. Forteath, Esq.; Clifton Grove, Sir Robert J. Clifton; Clumber Park, Duke of Newcastle; Colwick Hall (unoccupied); Elton Manor, W. F. N. Norton, Esq.; Flintham Hall, T. B. T. Hildyard, Esq.; Grove Hall, G. H. Vernon, Esq.; Holme Pierrepoint, Viscount Newark, M.P.; Kelham House, J. H. M. Sutton, Esq.; Kingston Hall, Lord Belper; Mapperley House, Ichabod Wright, Esq.; Newstead Abbey, late Lord Byron (now Colonel Wildman); Norwood Park, Sir John Sutton, Bart.; Nuttall Temple, R. Holden, Esq.; Osberton, George S. Foljambe, Esq.; Ossington Hall, Right Honourable J. E. Denison, M.P.; Oxton Grange, H. P. Sherbrooke, Esq.; Ruddington Grange, Charles Paget, Esq., M.P.; Rempstone Hall, Lady Sitwell; Rufford Abbey, Earl of Scarborough; Serlby Hall, Viscount Galway, M.P.; Stanford Hall, Rev. S. V. Dashwood; Thoresby Park, Earl Manvers; Thrump-

Noureddin. ton Hall, Honourable Captain Byron; Thurgarton Priory, Richard Milward, Esq.; Watnall Hall, Colonel Rollestone; Welbeck Abbey, Duke of Portland; Whatton Manor, T. D. Dickenson, Esq.; and Wollaton Hall, Lord Middleton. (S. M–LL.)

NOUREDDIN, or NOOR-ED-DEEN, the name of several Moslem rulers of Syria, of whom the most distinguished was NOUREDDIN MAHMOUD, *Melek-El-Adel*, who succeeded his father the famous Zenghi, Emir of Aleppo, in 1146. His reign was endangered at its commencement by the attempts of the Christians to regain the possessions which had lately been wrested from them. Josceline de Courtenay siezed upon his former capital Edessa: but he was speedily dislodged, and the rebellious spirit of the citizens was suppressed by an extensive massacre. The second crusade, under the command of Louis VII. of France and the Emperor Conrad, arrived in 1148. But the ranks of the Christian invaders had been wasted in their march by the shafts and scimitars of the infidels; their strength was now still further weakened by the dissensions of the royal leaders; and after sitting down for some time before Damascus, they returned ignominiously to Europe. It was about this time that Noureddin conceived the grand project of rearing an effectual barrier against future crusades by annihilating the dominion of the Christians in Palestine, and uniting all Syria and the neighbouring districts under one government. For achieving such an enterprise his character peculiarly qualified him. His pious zeal had raised him high in the estimation of his fellow-Moslems; his conscientious frugality specially adapted him for the management of military expeditions; on account of his majestic bearing and simple soldier-like manners, he had become the darling of his army; and for his just rule and merciful care for the poor and the oppressed, he was regarded as the father of his people. Accordingly, he began the enterprise with great vigour and success. Raymond, Prince of Antioch, was defeated and slain in 1149; Josceline de Courtenay, Count of Edessa, was taken captive soon afterwards; and the whole of Northern Syria became in consequence the possession of Noureddin. He then turned his attention to the gaining of Damascus. The course of events rendered force in this case unnecessary. Anar, the able vizier of that kingdom, died; the ruler Modjir-Ed-Deen was considered too imbecile to resist the threatened attack of Baldwin III., King of Jerusalem; and in 1154 the terrified inhabitants of Damascus willingly put themselves under the jurisdiction of the powerful and benign Emir of Aleppo. Noureddin had now extended his dominions around the borders of the Latin territories in Palestine, and had thus gained a favourable position for carrying out still further the great project of his reign. A severe illness, indeed, in 1159, and a defeat which the Christians inflicted upon him, gave a check to his success. But speedily recovering himself, he encountered the famous Reginald de Chatillon, prince of Antioch, defeated him, and took him prisoner. Taking advantage also of the distracted state into which the khaliphate of Egypt had been plunged by the contention for the viziership between two emirs, Shawir and Ed-Dirgham, he resolved to extend his influence into that country. Sheerkooh, and his nephew Salah-Ed-Deen or Saladin, were accordingly despatched at the head of an army to raise the former of the rivals to the contested office. At first the enterprise was unsuccessful. Shawir, after he had been placed in the viziership, refused to fulfil his obligations to Sheerkooh, and summoned in the aid of Amaury, the son and successor of Baldwin III. The troops of Aleppo were besieged in Pelusium, and were forced to capitulate to the Christians. At length, however, the tactics of Noureddin himself retrieved the declining fortunes of the Moslems. His inroad into the state of Antioch recalled Amaury to its defence; the Christian troops immediately on their arrival were routed near Tiresia with disastrous loss; and Sheerkooh being sent once more into Egypt, succeeded, in 1168, in removing the perfidious Shawir by death, and in establishing himself as lieutenant of Egypt in the name of his master. The schismatic khaliphate of the Fatimites in that country was then abolished; the Egyptians were restored to the spiritual jurisdiction of the Abasside khaliph of Baghdad; and that chief of the Faithful conferred upon his meritorious servant Noureddin the title of Sultan, and the direct investiture of Egypt and Syria. Noureddin might now have turned his vastly increased resources against the Latin states in Palestine, and might thus have achieved the magnificent result to which all his past successes had been tending. But the last few years of his life were molested by the ambitious intrigues of the able Salah-Ed-Deen, who had succeeded his uncle Sheerkooh in the lieutenancy of Egypt. He was on the eve of setting out to chastise his rebellious subject, when an attack of quinsey brought his days to a close at Damascus in May 1173. Novalis.

NOVALIS, the literary pseudonym usually applied to FRIEDRICH LUDWIG VON HARDENBERG, a distinguished philosopher and poet of Germany, who was born at a country house of his family in the county of Mannsfeld, in Saxony, on the 2d of May 1772. His father, a frank, rugged, honest German, had spent his early years as a soldier, but was at this time director of the Saxon salt-works. The mother of Novalis was "a pattern of noble piety and Christian mildness," and her son seems to have loved her with the most enthusiastic affection. From both his parents, who were attached to the Herrnhut communion, Novalis inherited that decidedly religious temper which continued to be the ruling principle of his life. In childhood he was very delicate, and was brought up in the most retired manner. He showed no interest in the boisterous sports of youth, and even shunned the society of his fellows. He remained in this dull, dreamy condition until his ninth year, when a dangerous illness shook his faculties from their slumber, and called forth the energies of a genius of uncommon power and originality. His elementary education was now prosecuted with great success; and he displayed an extraordinary fondness for history and poetry. The Traditionary Tale (*Märchen*), which he afterwards continued to admire, had at this early stage a peculiar charm for him; and one of his earliest literary endeavours was a composition of this sort, written for the amusement of his brothers and sisters. After a few months at a gymnasium, he repaired to Jena in 1790, where he prosecuted his studies for three years. He then removed with his brother Erasmus to the university of Leipsic, and after spending a season there, went to Wittemberg to complete his education. It seems to have been Jena, however, which exerted the most marked influence over his development. Here he first met Friedrich Schlegel, and it was here he first listened to the lofty eloquence of Fichte. The *Wissenschaftslehre*, or Doctrine of Science, of that distinguished thinker, was studied by Novalis with singular avidity. The charm of its refined idealism attracted the sympathies of an intellect of surprising subtilty; the stern grandeur of its morality called forth the enthusiasm of the youthful romanticist; and the burning eloquence and calm dignity of the teacher carried conviction to the heart of the student. The philosophy of Fichte formed accordingly the groundwork of all the subsequent speculations of Novalis. The Kantian distinction, and even occasional antagonism, of the Understanding and the Reason, is carried by him into all departments of mental development—into poetry, virtue, and religion. He learned to despise with the transcendentalists the dull, blind, pedestrianism of the Understanding, and sought to gain the citadel of truth by following the clear, steady light of the higher Reason. The whole of his writings have a constant reference to this specula-

Novalis.

tive theory, and can only be studied in the light of it. After displaying a strong predilection for a military life, his friends succeeded in prevailing on him to follow his father's occupation; and he accordingly removed to Arnstadt in Thuringia in 1794, to train himself for business. Having remained a year there, he was appointed auditor of the department of which his father was director, and took up his residence at Weissenfels. In the year 1797 events occurred which, according to his biographer Tieck, gave a shock to his whole nature, and imparted a gloomy complexion to his thoughts, from which he was not destined to recover. During his residence at Arnstadt he had become enamoured of a fair, delicate German girl, possessed of uncommon attractions, but with health exceedingly fragile. He had hardly known her a year when the chill spring winds came and withered the fair flower; and ere he had time to dry his tears, he had to follow the remains of his brother Erasmus to the grave. It was during this year that the greater number of those remarkable pieces of Novalis, called *Hymns to the Night*, were composed. Not a few of his *Fragments* also belong to the same period. In 1798 he removed to Freyberg to study mineralogy under the famous Werner. In the mathematical and physical sciences he took an eager interest; and if we may judge from the fragmentary papers which he has left, he seemed to have prosecuted the study on a great and original principle. He put together about this time his unfinished "physical romance" of *Lehrlinge zu Sais*, or the Pupils at Sais, so full of strange poetized philosophy and shadowy allegorical allusion. While here he formed another betrothment, destined like the first to be cut short by death. On his return to Jena he made the acquaintance of August Wilhelm Schlegel and Tieck, then engaged in the famous literary campaign in behalf of what is generally known as Romanticism. Tieck "re-awakened poetry in him," he says; and it was in conjunction with these men, whose cause he ardently espoused, that Novalis first presented his thoughts to the world. He contributed his *Blüthenstaub*, or Pollen of Flowers, together with numerous poetical pieces, to the *Musen-Almanach* of F. Schlegel; and composed about the same time his *Geistliche Lieder*, or Spiritual Songs, so remarkable for simple sublimity and still, devout pathos. In addition to his passionate love of nature, these were perhaps his highest poetic gifts. In the summer of 1800 we find him living at a solitary spot at the foot of the Kyffhäuser Mountain in Thuringia, busily engaged on his art romance of *Heinrich von Ofterdingen*, designed, as he said, to be an "apotheosis of Poetry." It was never completed, however, and was ere long published in its unfinished state. In his prose style he generally aims at simplicity and directness—qualities not always to be found in his poetry. Indeed, it may be questioned whether, with all the wealth of a truly regal genius, he was possessed of the highest faculties of the poet. If in the rich strength of his theosophic mysticism he resembles an oriental, the likeness is increased when we regard the soft passiveness of his mind and character. Carlyle, who calls him the "German Pascal," says, "The chief excellence we have remarked in Novalis is his, to us, truly wonderful subtlety of intellect; his power of intense abstraction, of pursuing the deepest and most evanescent ideas through their thousand complexities, as it were with lynx vision, and to the very limits of human thought." (*Miscellanies*, vol. ii., p. 95.) In August 1800, while Novalis was preparing for a journey to Freyberg to bring home his betrothed, he was seized with a spitting of blood, which ended in a rapid decline. Hope, gladness, and rich expanding activity had just begun to make life desirable to him, when death came with the spring of 1801, and ended his strange career, at the premature age of twenty-eight. A Life of Novalis, by his friend Tieck, will be found prefixed to *Novalis Schriften, herausgegeben von Ludwig Tieck und Friedrich Schlegel*, 2 vols., Berlin, 1802, and since frequently republished. A new edition of his Works, with various additions previously unpublished, appeared at Berlin in 1846, under the care of Tieck and Bulow.

Novara || Nova Scotia.

NOVARA, a town in the Kingdom of Sardinia, capital of a division and province of the same name, stands on a rising ground between the Agogna and the Terdoppio, 53 miles E.N.E. of Turin. It is well built, containing several good and well-paved streets; and was formerly surrounded by walls, but these have now nearly all disappeared. The cathedral is an ancient and handsome building, with a square tower surmounted by a cupola, and contains in the interior several fine paintings and sculptures. The church of St Gaudenzio is likewise a fine structure, and contains one of the best paintings of Gaudenzio Ferrari. Besides these and other churches, Novara contains public offices, a town-house, court-house, an episcopal palace and seminary, several upper schools, a theatre, hospital, barracks, and market-house. The manufactures of the place are not very extensive, and consist chiefly of leather, cotton cloth, candles, starch, pottery, and biscuits. The principal trade is in silk and rural produce, for the latter of which Novara is the chief emporium in Piedmont. Near the town a battle was fought in 1849, in which the Sardinians were totally defeated by the Austrians under Radetzky. The result of this engagement was the resignation of the crown of Sardinia by the king, Carlo Alberto, and the renunciation of the Sardinia claims on Lombardy. Pop. about 16,000.

The division of Novara is bounded on the N. by Switzerland and the Alps, E. by Lake Maggiore and the Ticino, S. by the Po, and W. by the divisions of Turin and Ivrée. Towards the N.W. it is occupied by the branches of the Alps; but the greater part consists of a fertile plain, watered by the Fosa, Sesia, Terdoppio, Agogna, Ticino, and other smaller streams. Corn, rice, hemp, pulse, &c., are grown here; and on the higher regions the vine is largely cultivated. The division of Novara is subdivided as follows:—

Provinces.	Area in sq. miles.	Pop. (1848).
Novara	533	178,069
Lomellina	480	139,049
Pallanza	312	64,030
Ossola	520	36,331
Valsesia	290	35,879
Total	2135	453,958

NOVA SCOTIA, a British province of North America, situated between N. Lat. 43. 25. and 46. 0., and W. Lon. 61. 0. and 66. 30., and connected with the S.E. part of the continent by an isthmus of only 8 miles in width. It is bounded on the N. by the Strait of Northumberland, which divides it from Prince Edward's Island; on the N.E. by the Gut of Canseau, which interposes between it and the island of Cape Breton; on the S. and S.E. by the Atlantic Ocean; on the W. by the Bay of Fundy; and on the N.W. by New Brunswick. Its extreme length, from Cape Canseau on the E. to Cape St Mary's on the W., is about 280 miles; but its breadth varies from 50 to about 100 miles; and it contains a superficies of 15,607 square miles. From this, however, about one-fifth may be deducted for lakes, arms of the sea, and rivers, leaving about 8,000,000 acres of land, the greater part of which is still uncleared, and covered with forests.

Surface.

The most remarkable characteristic of this peninsula is the numerous indentations along the coasts. The shores are lined with rocks, and studded with thousands of small islands; and close to these, and in the harbours, almost without exception, there is a considerable depth of water. All along the S.E. shore there is a succession of noble harbours; and vessels sail amongst and within the myriads of islands which line the coast during the most blustering

Nova Scotia.

Surface.

weather, thus enjoying comparatively smooth water, whilst the main ocean heaves in violent agitation. The principal inlets are Sheet Harbour, Halifax Harbour, Margaret's Bay, Mahon Bay, Shelburne Harbour, on the Atlantic; St Mary's Bay, 10 miles broad and 35 long; Annapolis Basin, 10 miles in length, and from 1 to 4 in breadth; Mines Basin, 50 miles long, and 16 broad at the widest part, on the Bay of Fundy, which is terminated by Chignecto Bay, between Nova Scotia and New Brunswick; Pictou Harbour, on Northumberland Strait; St George's Bay, on the Gulf of St Lawrence; and Chedabucto Bay, on the Gut of Canseau. Between Halifax and Cape Canseau there are said to be no less than twelve harbours capable of accommodating ships of the line, besides fourteen others accessible for merchantmen. The interior of the country is very agreeably diversified with hill and dale, river and lake, forest and grassy plain. The surface, although undulating, is not mountainous; the highest land, Ardoise Hill or Arthur's Seat, being only 810 feet above the level of the sea, nearly the same height as Arthur's Seat at Edinburgh. The high lands generally run parallel to the coasts, branching off in all directions, and in some instances terminating in bold cliffs on the coast, the most remarkable of which is Aspotagoen, between Mahon and Margaret's Bay, which is about 500 feet in height. A tract of rugged and hilly country stretches along the shore of the Atlantic, varying in breadth from 20 to 60 miles, and having an average height of about 500 feet. The North Mountains, which are washed by the Mines Basin, extend along the coast of the Bay of Fundy, and terminate in Cape Blomidon; and parallel to these run the South Mountains in the interior of the peninsula. The Cobequid Hills extend from the northern shores of Mines Basin towards Northumberland Strait, having a breadth of 10 miles, and a height of about 800 feet. There are several remarkable caverns and grottoes in Nova Scotia, one of which, at St Peter's Point, on the coast of the Bay of Fundy, displays in the interior a spacious hall, the roof of which is fretted with stalactites.

Rivers and Lakes.

The interior of Nova Scotia is intersected and watered by numerous rivers, lakes, and streams, which beautify and enrich the country. The two largest rivers are the Annapolis and the Shubenacadie. The former takes its rise in King's County, and, running parallel with the Bay of Fundy, after a long and serpentine course, in which it receives the Moose and Bear Rivers, discharges itself into Annapolis Bay. It is navigable to a considerable extent, and its banks present a rich and pleasing landscape. The Shubenacadie, issuing from the Grand Lake in the county of Halifax, divides that county from Hants, and, after a rapid and circuitous course, the length of which has not yet been accurately ascertained, discharges itself into the Bay of Mines. It receives the waters of ten other rivers, is navigable for large vessels a long way into the interior, and contains on its banks inexhaustible quantities of gypsum and lime, together with extensive groves of fine timber. At Pictou, three rivers, navigable for large vessels, empty themselves into the harbour; the East, West, and Middle Rivers. Besides these, there are the Avon, navigable for a considerable distance; the La Have, which issues from a chain of inland lakes, and has a course of about 60 miles; the Mersey, which winds from Lake Rosignol through the Queen's county, and discharges itself into Liverpool Harbour; the Medway, the Shelburne, the Clyde, the Tusket, the St Mary, and others, all of which owe their origin to lakes in the interior. A canal, called the Shubenacadie Canal, together with a chain of lakes, forms a communication by water across the peninsula from Halifax Harbour to Cobequid Bay, at the head of the Mines Basin. The most extensive still sheet of water is the Rosignol, situated partly in each of the three counties of Queen, Shelburn, and Annapolis. It is said to be 30 miles in length, but is little known. Lake George is also of considerable size; and there are innumerable others which it is unnecessary to mention.

Nova Scotia.

Climate.

The climate of Nova Scotia was for many years after its discovery considered as an insuperable barrier to agricultural industry, and an idea long prevailed in England that it was peculiarly the region of snow and fog. The temperature is indeed colder in winter in this peninsula than it is in Great Britain; but when the weather is cold it is usually dry; and altogether the winter is milder, and the summer less intensely hot, than at Quebec. The summer heat is moderate and regular; the autumn is a delightful season; and there is seldom any severe winter weather until the end of December. Frost continues generally from Christmas to April, and the spring is of very short duration. The temperature varies during the year from 6° or 8° Fahr. below zero, to 80° above it, the average of the coldest month at Halifax being about 20°, and that of the hottest about 70°. Like other parts of North America, however, Nova Scotia is subject to sudden changes of temperature, sometimes as much as 50° in twenty-four hours. The mildness of the climate seems to be owing in some degree to the influence of the gulf-stream, which prevents the harbours on the Atlantic from being frozen up in winter like those on the northern coast.

Geology.

There is a great variety of rocks in Nova Scotia, but granite, trap, and clay-slate predominate. The most abundant variety is the gray granite, which, together with gneiss and mica-slate, prevails along the shore, and is well adapted for mill-stones. Trap rocks, sometimes imbedded in clay-slate, protrude in various places in immense parallel ridges above the surface, and frequently in piles of loose masses heaped confusedly together, traversed frequently by veins of quartz. Clay-slate of a very fine quality, and used as a building stone, prevails in the eastern section of the colony; and graywacke and graywacke-slate extend along both shores of Chedabucto Bay, in which are found beds of limestone and numerous specimens of specular iron ore. In connection with carboniferous limestone are found, both in Cape Breton and Nova Scotia, those immense coal-fields which are supposed to rival in extent the mines of the mother country. The coal is of a bituminous character, and entirely different from that which is found in the United States, east of the Appalachian Mountains. It is of various kinds, some of which are well fitted for the use of the smith, others for that of steamboats, and others for gas-making. In the coal formations of this country there is also found an immense quantity of gypsum, which is largely exported to the United States. Varieties of copper, iron, and lead ores are also abundant; and different other minerals of less importance are found. Fine specimens of agates, amethysts, chalcedonies, jaspers, and other stones, are obtained in Nova Scotia. Salt springs, some of them strongly impregnated with saline matter, are met with near Pictou, at River Philip, and some other parts.

Zoology.

The wild animals are the moose, carriboo, bear, lynx, fox, marten, otter, mink, beaver, musk-rat, porcupine, racoon, weasel, squirrel, hare, and the like, all of which, excepting the two last, have rapidly decreased in number. Nearly all the birds common to North America frequent Nova Scotia; and there are but very few kinds of fish which are found in the American seas that do not frequent the shores of this colony in vast swarms. The lakes and rivers abound in trout and salmon.

Soil.

The soil is of many different qualities, and various degrees of fertility. The alluvial or intervale lands, of which there are extensive tracts, are rich, and produce plentiful returns of wheat, barley, oats, Indian corn, potatoes, turnips, with all the vegetables and fruits common in England. Some of the uplands, lying between the hilly country and the rivers, are light and poor; whilst the high

Nova Scotia.

lands are rich and very productive. The lands on the Atlantic coast are generally so rocky as to admit of cultivation only at much expense and labour; but after the stones are removed, the soil is by no means barren. The forests of Nova Scotia still constitute a prominent feature of the country. The trees are the same as those common to America, and the timber is generally large and lofty.

Agriculture.

Agriculture is carried on to a considerable extent in Nova Scotia. The cultivated ground consists partly of the rich alluvial marshes on the shore of the Bay of Fundy, and partly of the uplands in the interior of the country. The former kind of ground, which has been recovered from the sea by means of dykes, was estimated in 1850 to amount to 40,012 acres; and the latter to 799,310 acres. The produce in 1852 was 297,157 bushels of wheat, 196,097 of barley, 61,438 of rye, 1,384,437 of oats, 170,301 of buckwheat, 37,475 of maize, 21,638 of pease and beans, 3686 of grass seeds, 1,986,789 of potatoes, 467,127 of turnips, 32,325 of other roots, 287,837 tons of hay, 3,613,890 lb. of butter, and 625,069 lb. of cheese. The amount of live stock in the same year was 28,789 horses, 156,857 neat cattle, 86,856 milch cows, 282,180 sheep, and 51,533 swine.

Sable Island.

Sable Island, although distant about 85 miles from Nova Scotia, is considered as belonging to that province. It lies directly in the track of vessels bound to or from Europe, and has been the scene of numerous and melancholy shipwrecks. It is 25 miles in length, by about 1¼ in breadth, the eastern end being in Lat. 43. 59. N., and Long. 59. 45. W. It is a barren desert throughout, the soil consisting chiefly of sand, and the only vegetable productions being a coarse grass and some wild pease. A sum, which amounted in 1854 to L.1977, is annually devoted to keeping on the island a superintendent from Nova Scotia, with a party of men provided with provisions and other necessaries, for the purpose of affording assistance to any shipwrecked mariners, of whatsoever nation, who may be driven on its inhospitable shores. There is a small stock of cattle on the island, and a large number of wild horses, but the chief supplies of food are obtained from Nova Scotia.

Manufactures and commerce.

The manufactures are few in number, consisting principally of coarse cloth, flannel, carpets, hats, paper, tobacco, leather, spirits, and agricultural implements. The province contained in 1850, 1153 saw-mills, employing 1786 hands; 386 grist-mills, employing 437 hands; 10 steam-mills; 237 tanneries; 9 foundries; 81 carding and weaving establishments; 17 breweries and distilleries; and 131 other manufactories of various sorts. In the same year there were raised in Nova Scotia 114,992 chaldrons of coal; there were quarried 79,795 tons of gypsum, valued at L.10,498; 28,603 casks of lime, valued at L.4433, were burned; 2,845,400 bricks, valued at L.3211, were made; and 110,441 lb. of maple sugar were produced. In the same year the value of leather manufactured was L.52,625; of boots and shoes, L.73,654; of iron smelted, L.4635; of castings, L.3486; of soap, L.28,277; and of candles, L.21,210. Ship-building is also carried on in Nova Scotia. The number of vessels constructed in 1854 was 244, and their tonnage 52,814. Besides farming, the chief occupation of the inhabitants is fishing; and some combine both pursuits. There were in 1851 employed in the fisheries of Nova Scotia and Cape Breton 812 vessels, with a tonnage of 43,333, and manned by 3681 men; 5161 boats, with 6713 men; and the number of nets and seines was 30,154. The quantity of fish cured was 196,434 quintals; and there were also obtained 1669 barrels of salmon; 3536 of shad; 100,047 of mackerel; 53,200 of herring; 5343 of alewives; and 15,409 boxes of smoked herrings, valued at L.217,270; as well as 189,250 gallons of fish oil, valued at L.17,754. The total value of the fisheries is estimated to exceed L.200,000. The exports of the province consist principally of fish, sugar, molasses, rum, cotton and woollen goods, timber, &c. The total value of the exports in 1854 was L.1,247,668. The principal articles imported are flour, sugar, tea, manufactured goods, &c.; the total value of the imports in 1854 was L.1,791,082. The number and tonnage of the vessels that entered and cleared in 1851 were as follows:— Nova Scotia.

Countries.	Entered.		Cleared.	
	Ships.	Tons.	Ships.	Tons.
United Kingdom	107	47,744	74	38,728
British Colonies	1447	104,611	1595	133,607
United States	1581	159,676	1436	152,202
Other Countries	267	28,008	142	13,501
Total	3402	340,039	3247	338,038

Government.

The executive power in Nova Scotia is in the hands of a lieutenant-governor, and a council of six membsre. The legislature consists of a council of nineteen, appointed by the governor, subject to the approval of the crown; and a House of Assembly, of fifty-one members, elected by the people. The system of responsible government has been established in Nova Scotia since 1848. The lieutenant-governor has a salary of L.3000 a-year. The judicial establishment consists of a supreme court, composed of a chief-justice and four assistant judges; which sits at Halifax three times a-year, and makes two annual circuits of the province; a court of error, composed of the lieutenant-governor and executive council; a court of chancery; courts of general sessions of the peace; courts of vice-admiralty; a court of marriage and divorce; and courts of probate. The established religion is Episcopalian: Nova Scotia was created a diocese in 1787, and has a bishop, an archdeacon, and fifty other clergymen; the two first being supported by an endowment from the home government, and the others by the Society for the Propagation of the Gospel. The amount of public expenditure for ecclesiastical purposes in 1854 was L.3687. There is a Synod of Nova Scotia in connection with the Established Church of Scotland, and various churches in connection with the Free Church of Scotland and the United Presbyterian Church. The Roman Catholic Church has two dioceses, Nova Scotia and Cape Breton, within the province. The whole number of churches in 1851 was 567; and the adherents of the various denominations were as follows:— Religion.

Church of England	35,482	Baptists	42,243
Church of Scotland	18,867	Methodists	23,596
Free Church of Scotland	27,280	Congregationalists	2,639
United Presbyterians	28,767	Lutherans	4,087
Roman Catholics	29,634	Other sects	4,660

Education.

Nova Scotia contains several colleges, besides inferior educational establishments. King's College at Windsor resembles the English universities, and Dalhousie College at Halifax those of Scotland. There are also a Free Church college, a Baptist college, and a Roman Catholic college. None of the attempts which have been made to unite some of these colleges into a university has proved successful. Each of the counties in the province has a grammar school; and the total number of schools in Nova Scotia in 1851 was 1096, attended by 31,354 scholars. The amount of public money expended on education in 1854 was L.13,401.

Army.

The military forces of the province consist of twenty-six regiments of militia, 26,248 strong, but which might soon be raised to nearly double that number. Besides this, Nova Scotia is protected by two or three regiments of the line, which are always stationed in the garrison towns, and by the visits during the summer of the squadron of the Royal Navy. The principal fortifications in the province

Novatianus

are at Halifax, at Windsor, at Annapolis, and at Cape Breton. The revenue is chiefly derived from a duty on imported goods, and amounted in 1854 to L.166,501, while the expenditure for the same year was L.169,159.

Inhabitants.

The inhabitants of Nova Scotia consist of English, Scotch, Irish, Americans, Germans, Swiss, Acadian French, Indians, and freed Negroes. They mingle and live together in much harmony, and generally the social state of the province is rapidly improving. Its prosperity has greatly increased; and, instead of importing, it now exports provisions. Its fisheries, to which proper attention is at length paid, its rich and prolific soil, and its mines of coal and iron, are sources of wealth which were too long neglected by Great Britain.

The province is divided into eighteen counties, including Cape Breton, as follows:—

Counties.	Pop. (1851).	Capitals.
Halifax	39,112	Halifax.
Lunenburg	16,395	Lunenburg.
Queen's	7,256	Liverpool.
Shelburne	10,622	Shelburne.
Yarmouth	13,142	Yarmouth.
Digby	12,252	Digby.
Annapolis	14,286	Annapolis.
King's	14,138	Kentville.
Hants	14,330	Windsor.
Cumberland	14,339	Amherst.
Colchester	15,469	Truro.
Pictou	25,593	Pictou.
Sydney	13,467	Antigonishe.
Guysboro'	10,838	Guysboro'.
Inverness	16,917	Port Hood.
Richmond	10,381	Arichat.
Cape Breton, Victoria	27,580	Sydney, Bedeque.
Total	276,117	Halifax.

History.

Our limits will only admit of a brief abstract of the history of Nova Scotia. Ancient authorities state that it was discovered by the Cabots in 1497; but it was not until 1604 that the French attempted to form settlements. They were, however, expelled from it in 1614 by the English colonists of Virginia, who claimed the country in right of the discovery of Sebastian Cabot. In 1621 Sir William Alexander obtained a grant of the whole peninsula, and it was named in the patent Nova Scotia, instead of Acadia, as the country was called by the French. In the meantime the latter obtained a footing in it a second time; and it was not until 1654, when a strong force was despatched by Cromwell, that the French settlers were brought under subjection. In 1667 Nova Scotia was ceded to France by the treaty of Breda; but, after suffering during the war which broke out in 1701, as well as previously, it was finally ceded to England by treaty in the year 1711. From this period till 1749 it was neglected by Great Britain; but the designs of the French called the attention of government to the province. Encouragements were held out to settlers; Parliament gave a large grant; and about 4000 adventurers, with their families, embarked for the colony. Halifax was immediately founded; but the French settlers, under the name of neutrals, were still very numerous; and, with the aid of the Indians, they inflicted repeated injuries upon the British, until they were forcibly expelled by the latter. In 1758 a constitution was granted to Nova Scotia; and the capture of Louisburg, in the island of Cape Breton, during the same year, gave additional security to the colony, which now began to improve. By the treaty of Paris, 10th of February 1762, France resigned all further claims on any of her former possessions in North America, and nothing of any material importance has since occurred. New Brunswick and Cape Breton were separated from Nova Scotia, and formed into two distinct governments, in 1784, but the latter was re-annexed to Nova Scotia in 1819.

NOVATIANUS, the founder of the sect of the Novatians, was, according to Philostorgius, a native of Phrygia, and was born about the beginning of the third century. The religious intolerance of his opponents has falsified his life, and has represented him as little else than a hypocritical time-server. But the account which is most consistent with the growth of his peculiar opinions is the following:—His conversion took place after an intense mental struggle, and he was baptized when he was lying on a sick-bed, in hourly expectation of death. On his recovery, his religious sentiments retained a tinge of that gloom under which they had sprung into life. Admitted into the priesthood, he devoted himself to the severe theological studies and the ascetic penances of the cloister. It is not surprising, then, that his spirit was shocked at the easy terms on which those who had relapsed into idolatry during the Decian persecutions were re-admitted into ecclesiastical communion. He began to maintain boldly that the church had no warrant from Scripture to pardon the sins of those who, after their baptism, had sacrificed to idols: that her sole duty in this case was to exhort them to repentance, and to commend them to the mercy of God. The learning, eloquence, and virtuous life of the new reformer soon drew a party around him. Among others, Novatus, a Carthaginian priest, joined the dissentients, and by his hot-headed zeal speedily hurried the controversy into an open schism. Advantage was taken of the martyrdom of Fabianus, Bishop of Rome, in 250, to disown the authority of Cornelius, the successor to the vacant see, and to set up Novatianus as his rival. The result was, that at a council convened at Rome in 251, the Novatians and their leader were excommunicated. Thus compelled to organize a new sect, the heresiarch set himself to develop his peculiar opinions. The following became the distinguishing tenets of his creed:—(1.) That not only sacrificing to idols, but all mortal sins, such as adultery and temporizing in any way with idolatry, ought to debar backsliders from re-admission into the church. (2.) That if this regulation were not maintained, the church would become defiled, and would no longer be (as it ought to be) a community of believers who had never fallen since their baptism into any other than venial offences. This testimony Novatianus is said to have sealed with his blood. After his death, his followers, in spite of much persecution, rapidly increased and spread themselves over Christendom. They continued to vindicate their right to be considered the true church, by calling themselves καθαροί (*Puritans*), and by re-baptizing all proselytes from other Christian sects. However, they did not maintain their existence as a separate sect for much longer than two centuries.

Of the several works in which Novatianus displayed his methodical reasoning, his pure and elegant diction, and his animated style, three authenticated writings alone remain. These are a letter written in the name of the Roman clergy to Cyprian in 250, and two treatises entitled respectively *De Trinitate*, and *De Cibis Judaicis*. They have been published collectively by Welchman, 8vo, Oxford, 1724, and by Jackson, 8vo, London, 1728. The two treatises are also generally found in the editions of Tertullian.

Nova Zembla.

NOVA ZEMBLA, or Novaïa Zemlia, a name which signifies in Russian "New Land," is applied to an island, or rather chain of islands, in the Arctic Ocean. It extends from N.N.E. to S.S.W., curving slightly towards the W., and lies between N. Lat. 70. 30. and 76. 30., E. Long. 51. 30. and 77. It is washed on the W. by the Spitzbergen Sea, and on the E. by the Kara Sea; which, along with Burrough's Strait, separates Nova Zembla from the continent and from the island of Vaigats. Its whole length is about 500 miles, with an average breadth of about 50. The most southerly island of the chain is separated from the rest by a strait called Matochkin Shar, or Matthew's Strait; and farther to the N. there is another strait called Cross Bay, which divides itself into several arms, and forms other small islands. The southern island alone is properly called

Novel || Novgorod.

Nova Zembla; the middle one, which is much smaller, is known by the name of Matthew's Land; while to the N. lie Lütke's Land and Barent's Land, believed to form one continuous island. The eastern shores of all the islands are low; but on the W. the land is mountainous, rising in general 2000 feet above the sea, and the highest summit, near Matthew's Strait, is 3475 feet in height. The formation of the mountain is for the most part black clay-slate; and in the southern islands grey limestone, like that of the northern part of the Ural chain. The climate of these islands is indicated by the following table:—

Place.	N. Lat.	E. Lon.	Mean Annual Temp.	Mean Summer Temp.	Mean Winter Temp.
South extremity.	70. 37.	57. 47.	14°·99	35°·59	3°·21
Matthew's Strait.	73. 0.	57. 20.	16·93	38·49	2·29
Cross Bay.....	74. 0.	58. 0.	20·74	36·60	9·78

The vegetation is very scanty, consisting only of mosses and lichens; in many parts the ground is quite barren; and notwithstanding the long continuance of the sun above the horizon, the soil is never thawed more than a foot or two deep. Animal life is as scarce here as vegetation. Nova Zembla is often visited by fishermen from Archangel in pursuit of the walrus. It was visited at an early period by the Russians, but was first brought into notice by Steven Burrough, who made a voyage thither in 1556. The west and part of the east coast were visited in 1596 by the Dutch navigator Barents; and several Russian expeditions have been sent out from Russia within the present century to explore the islands.

NOVEL. See ROMANCE, part ii.

NOVELDA, a town of Spain, province of Alicante, and 15 miles W. of the town of that name. The streets are pretty regular, and the houses, which are mostly of stone, are generally well built. Some trade in fruit and agricultural produce is carried on; and after agriculture, distilleries and oil-mills principally afford employment to the population, which amounts to about 9000.

NOVELLARA, a town of Northern Italy, duchy of Modena, and 16 miles N.W. of the town of that name. It is the capital of a principality annexed to Modena in 1737; and carries on some silk and leather manufactures. Pop. 4100.

NOVEMBER, the eleventh month of our modern year, was the ninth in the old Roman calendar. On this account the name *November* or *Novembris* (from *novem*, nine) was assigned to it in the Alban calendar. It consisted originally of thirty days, but Julius Cæsar added one to it. Augustus, however, again reduced it to its original number, which it has ever since retained. (See CALENDAR.)

NOVGOROD, or NOVOGOROD, a government of Russia, lying between N. Lat. 57. 18. and 61. 8., E. Long. 30. 10. and 39. 40.; and bounded on the N. by Olonetz, E. by Vologda and Yaroslaw, S. by Tver, and S.W., W., and N.W. by Pskov and St Petersburg; area, 46,833 square miles. The country is diversified with hills, valleys, plains, marshes, rivers, and lakes; the northern part is in general low and flat; but in the south the Valdai hills stretch for about 100 miles from S.W. to N.E., though these do not exceed 300 feet in height. The principal rivers are the Msta, which enters the government from Tver, flows north-west, and falls into Lake Ilmen; the Lovat, Pola, and Schelen, which fall into the same lake; the Volchov, which flows from that lake into the Ladoga Canal; the Schekona and Vologda, tributaries of the Volga; and the Sias and Buscha, which fall into Lake Ladoga. There are altogether in the government forty-two rivers, and fifty-five small, besides three large lakes. Of these last, the most extensive is the Bielo Osero, or White Lake, in the north-east, which is 26 miles in length, about as much in breadth, and 432 square miles in extent. Lake Ilmen, near the western extremity, has a length of 26 miles, a breadth of 16, and an area of 346 square miles; and Lake Vosche has a length of 14 miles, and an area of 177 square miles. There is a canal, 5 miles in length, connecting the rivers Msta and Volchov, by which navigation is carried on without passing through Lake Ilmen, as that extensive sheet of water is liable to dangerous storms. The soil in the southern parts is good and productive; but in the north it is very swampy, consisting for the most part of peat bogs. The climate is cold, and the winter long, lasting from November to May; while in the northern parts the cold is extreme, and the winter about a month longer than in the south. A large part of the land is covered with dense forests of pine, fir, birch, alder, elm, and other trees, which supply abundance of timber for export, and give shelter to great numbers of deer, elks, bears, wolves, lynxes, and other wild animals. The people are chiefly engaged in agriculture; and the principal crops are rye, barley, oats, buckwheat, potatoes, pease, flax, and hemp. Although there is much fine pasture ground, the inclemency and length of the winters prevent the rearing of more cattle than is necessary for farming; horses, oxen, and sheep of the common Russian breeds, and a few goats and pigs, are kept. Next to agriculture, fishing is the most general occupation of the people; it is carried on with great success on the lakes and rivers. Coal, iron, freestone, slate, lime, marl, &c., are among the mineral produce of Novgorod; and there are also good salt springs. The manufactures are not very extensive; and consist of coarse linen, soap, candles, potash, &c. Distilling, iron-smelting, and bell-making are also carried on. The exports of the province consist entirely of home produce, especially corn, hemp, flax, iron, timber, salt, hides, and furs. The principal place of trade is Novgorod, the capital. The government is divided into ten circles. Pop. (1846) 907,900.

Novgorod

NOVGOROD, the capital of the above government, stands on the Volchov, where it issues from Lake Ilmen, 120 miles S.S.E. of St Petersburg. It is one of the most ancient towns in Russia, having been founded in the fifth century of the Christian area by the Sclavonians, who had long previously invaded Europe, and followed a wandering mode of life. Their government was at first democratic, but dissensions having broken out and greatly weakened their power, Ruric was invited in the ninth century to assume the government, and he established at Novgorod the original foundation of the Russian monarchy, the seat of which was soon afterwards removed to Kiev. Novgorod afterwards acquired many privileges from the Russian archdukes; and in the twelth century became an independent republic under a hereditary magistrate of limited power. In the thirteenth century a factory of the Hanseatic League was established here; and for a long time Novgorod was the most important commercial city in the north-east of Europe. Its fairs were resorted to by the Hanse merchants, and by people from all the neighbouring countries; and in the fifteenth century it is said, though not probably with truth, to have contained 400,000 inhabitants. Indeed, so great was its power and prosperity at this time as to give rise to the saying, "Quis contra Deum et magnam Novogorodiam." But this did not last long; for in 1477 its independence was completely destroyed by Ivan Vassilievich I.; and in 1570 Ivan IV. took occasion, from a treasonable correspondence of some of the citizens with Poland, to massacre more than 25,000 of the inhabitants. The trade of the place was still considerable, until the foundation of St Petersburg, which monopolized the Baltic trade, and completely destroyed the importance of Novgorod. It now presents most unmistakeable marks of fallen greatness in its ruinous buildings, dilapidated walls, and grass-grown streets. The Kremlin, or fortress, stands on the north side of the river, and is connected by a fine stone

Novgorod-Sieversk ‖ Nowanuggur.

bridge with the commercial town and *Sophiskaia* on the other side. There are numerous churches, the principal of which is the cathedral in the Kremlin; three monasteries, a bazaar, a palace, a poor-house, and an orphan school. Sail-cloth, leather, soap, and candles are manufactured. Pop. 16,781.

NOVGOROD-SIEVERSK, a town of Russia, capital of a district in the government of Tschernigov, stands on the right bank of the Desna, 109 miles E.N.E. of Tschernigov. It is surrounded by walls, and has a castle, but neither is in a good state of repair. An active trade in corn, hemp, and lime is carried on; and several large fairs are held annually. Pop. (1849) 10,544.

NOVI, a town of Northern Italy, capital of a cognominal province in the division of Genoa, is situated in the plain of Marengo, at the foot of the Apennines, 25 miles N.N.W. of Genoa. It is surrounded by an old dilapidated wall; and of its old castle few remains now exist. The streets are irregular and narrow; but in the centre of the town is a handsome square adorned with a beautiful marble fountain. The principal public building is an ancient church, a fine old edifice with two towers; and some of the old houses are noted for their picturesque appearance. It is the seat of civil and commercial tribunals; and has a college, two monasteries, a theatre, and foundling hospital. Novi has an active trade; and carries on various manufactures, the chief of which is silk, for which it is one of the most celebrated places in Italy. In the neighbourhood a severe action took place in 1799 between the French and Austro-Russians, in which the former were defeated. Pop. 10,500. The province has an area of 288 square miles, and contained, in 1848, 65,013 inhabitants.

NOVI-BAZAR, a town of European Turkey, capital of a cognominal sanjak in the government of Bosnia, is situated on the Rashka, 130 miles S.E. of Bosna-Serai. It is a place of some trade; and has several warm baths. Pop. about 8000.

NOVICE, a person not yet skilled or experienced in an art or profession. In the ancient Roman militia, *novicii* or *novitii* were the young raw soldiers, distinguished by this appellation from the veterans. In the ancient orders of knighthood there were novices or clerks in arms, who went through a kind of apprenticeship ere they were admitted knights. Novice is more particularly used in monasteries for a religious person in his or her noviciate or year of probation, and who has not taken the vows. In nunneries the novices wear a white veil, the rest a black one. The custom of giving novices the religious dress was not known before the twelfth century. The Council of Trent fixed the age of profession at sixteen years.

NOVO-REDONDO, a seaport-town and fort of S.W. Africa, belonging to the Portuguese. The town occupies the summit of a rock at the mouth of the River Redondo, and is inhabited almost solely by free Negroes.

NOVO-TSCHERKASK, a town of European Russia, capital of the country of the Don Cossacks, on the River Don, about 40 miles from its mouth. It was founded in 1806 in consequence of the unhealthiness of old Tscherkask, the then capital. It is the seat of the government offices; and is well laid out with broad and regular streets, the houses being generally of one storey. It has a cathedral and numerous other churches, a college, and several schools, and a large hospital. Pop. (1850) 17,875.

NOWAGURH, a raj of India, subject to the political agent for the S.W. frontier. Its centre is in Lat. 20. 20. N., Long. 82. 25. E.; and it has an area of 1512 square miles. Pop. estimated at 68,000. The country is said to be among the worst governed of those within the circle to which it belongs.

NOWANUGGUR, a town of India, peninsula of Kattywar, province of Guzerat, 310 miles N.W. of Bombay. It stands on a creek indenting the S. shore of the Gulf of Cutch; and carries on a great trade, being the principal place of the district of Hallar, which is estimated to contain a population of 207,680. The town itself is nearly 4 miles in circuit, and is celebrated for its manufactures of fine cloth, as well as for the dyes given to that article. Copper ore has been discovered in a range of hills in the vicinity.

Nox ‖ Nubia.

NOX, one of the most ancient deities among the heathens, and the personification of Night. She was daughter of Chaos, and from her union with her brother Erebus, she gave birth to the Day and the Light. She was also the mother of the Parcæ, Hesperides, Dreams; of Discord, Death, Momus, Fraud, &c. Nox is called by some of the poets the mother of all things, of gods as well as of men; and Homer makes her the subduer of gods and men, Zeus himself being awed by her. (*Il.* xiv.) She was worshipped with great solemnity by the ancients, and had a famous statue, executed by Rhœcus, in the temple of Diana at Ephesus. It was usual to offer her a black sheep, as she was the mother of the Furies; and a cock was also presented to her, as that bird proclaims the approach of day during the darkness of the night. She is represented as mounted on a chariot, and covered with a veil bespangled with stars. The constellations generally went before her as her constant messengers. Sometimes she is seen holding under her arms two children, one of which is black, representing Death, and the other white, representing Sleep. Some of the poets have described her as a woman veiled in mourning, crowned with poppies, and on a chariot drawn by owls and bats. (See Hesiod, *Theog.*; Euripides, *Orestes* and *Ion*; also Pausanias.)

NOY, *Sir* WILLIAM, an attorney-general, whose conduct was one of the great causes of the civil war in England, was born in 1577. During the former part of his career his sentiments were patriotic, and he was distinguished in Parliament as one of the most formidable opponents of the despotism of Charles I. No sooner, however, had he been appointed attorney-general in 1631, than he was suddenly transformed into one of the most pliant tools of the king. The legal knowledge and ingenuity of the political apostate began to be employed in extorting from the constitution certain precedents which might countenance the tyranny of his royal master. He consummated his treachery to his country by devising the project of levying ship-money. But before he had seen the disasters which that act of his contributed to bring upon the land, he died, in 1634. Among his valuable legal works are, *A Treatise of the Principal Grounds and Maxims of the Laws of England*, of which the seventh edition was published in 12mo, 1806; and *The Compleat Lawyer*, of which the latest edition was published in 8vo, 1674.

NOYON (anciently *Noviomagus*), a town of France, department of Oise, on the Vorse, a tributary of the Oise, 42 miles E.N.E. of Beauvais. The town is ancient, but well built; and is surrounded with numerous gardens. It was formed into a bishopric in 531; and its cathedral is a fine Romanesque edifice of the twelfth and thirteenth centuries. Charlemagne resided here; and Hugh Capet was here elected king of France in 987. Noyon is, however, chiefly remarkable as the birth-place of the Reformer John Calvin. Manufactures of linens, hosiery, leather, &c., are carried on, and a brisk general trade. Pop. 6322.

NUBIA, a large country of Africa, lying between Egypt on the N. and Abyssinia on the S., the Red Sea on the E. and the Great Desert on the W.; and extending from N. Lat. 11. to 24., E. Long. 25. to 36. The name, however, is not always applied to the whole of this region, but is restricted by some geographers to the country east of the Nile, while the natives themselves apply the terms *Nooba*, or *Wady-el-Nooba*, to a comparatively small por-

tion between Derr and Dongola. It is about 850 miles in length, and upwards of 600 in breadth; while its area is estimated at 360,000 square miles.

Character of the country.

The aspect of the country in Lower Nubia is very different from that of Egypt, though both alike form part of the valley of the Nile. The mountains, which consist chiefly of sandstone and granite, approach much nearer to the river, leaving only a narrow strip of arable land along the water's edge; and the rocks in some places extend into the bed of the river, forming rapids, the lowest of which, called the First Cataract, occurs at the confines of Egypt and Nubia. Beyond the hills which line the river on either side stretches the desert of Nubia, extending on the one side to the Red Sea, and on the other being separated from the Sahara only by inconsiderable hills and table-lands. In some places the desert comes quite close to the Nile, forming sandy banks to the river, and in other places the banks are covered only with a thin strip of vegetation. Upper Nubia occupies the lowest of the three table-lands which are supposed to constitute this part of the African continent. The elevation increases towards the southern border of Nubia, which has a height of 4000 feet above the sea. This district is also occupied by several mountain chains, which do not for the most part, as in Egypt, extend parallel to the river, but from west to east, forming numerous valleys in the same direction. Of these chains the most important are the Gebel Snigrè, Gebel Safieha, and Orbay Langay; the last of which stretches from Faka on the Albara to Suakim on the Red Sea, and has numerous offshoots in the eastern Nubian desert. A range of mountains stretches along the coast of the Red Sea, but these are not very high, nor in any way remarkable. Coarse grey granite, quartz, and mica-slate are the chief geological formations of Upper Nubia. Gold and silver mines are said to exist near the shores of the Red Sea; but all the attempts made by the Pasha of Egypt to work them have proved fruitless. In Upper Nubia the Nile is not so closely shut in by mountains as in the lower region; and this country is also watered by other rivers, which discharge their waters into it. At the Second Cataract immense plains stretch out from either margin of the stream, exhibiting, it is said, even in their present neglected condition, unequivocal indications of fertility; and as there seems to be little doubt that in former ages the annual inundation extended considerably beyond the limits of modern cultivation, so it may reasonably be presumed that anciently the country was much more productive and populous than in modern times, when the decrease of the inundation, and the continual encroachment of the moving sands of the desert on either side, have combined to produce the desolation which now prevails. At present the Nile seldom or never overflows its banks in this part of Nubia; and the portion of the soil cultivated is irrigated by means of *sakkeas*, or Persian wheels constructed for raising the water of the river to the level of the adjacent ground. The eastern bank of the Nile is much better adapted for cultivation than the western, being more easily irrigated by artificial means. But it is not a little remarkable, that all the splendid ruins for which this region is distinguished, and which exhibit so great labour, ingenuity, and skill, are found upon the opposite bank; a circumstance which seems to strengthen the presumption that Nubia was formerly much more fertile and populous than in the present day.

Divisions of Nubia.

The country on the banks of the Nile is composed of two parts,—Wady Kenoos and Wady Nooba, so called from the tribes who inhabit them, and who differ from each other in language. The former extends from the confines of Egypt on the south to Wady Sebooa; and the latter, from which the general name of the country appears to have been derived, stretches as far as the frontier of Dongola. The chief distinction between these two parts consists in the circumstance, that the languages spoken in each are entirely different.

The grain which forms the principal object of Nubian cultivation is dhourra, the *Andropogon sorghum* of botanists. It is raised upon the patches of soil irrigated by means of the sakkeas or Persian wheels, of which there are from 600 to 700 between the First and Second Cataracts; and, when ground, it is formed into a cake somewhat resembling the Abyssinian *teff*. After the dhourra, the Nubians raise a crop of barley, French beans, lentils, and sometimes also of water-melons. Sometimes a third crop is raised in the year, and this in these cases generally consists of dhourra again. Tobacco is everywhere cultivated, and constitutes the principal luxury of all classes, being either smoked or sucked in a peculiar manner between the gums and the lip. Animal food is scarce, and seldom eaten, even by the chiefs or sheiks. The liquors used are palm-wine, a spirit distilled from dates, and a sort of beer called *booza*, which is made from dhourra. Excessive indulgence in these liquors is general throughout the whole country. The only fruit trees cultivated in Nubia are palms, but the soil is adapted for several others. Great sameness prevails in the vegetation of the desert, the trees being mostly acacias, tamarisks, date and doum palms.

Climate.

The climate of Nubia, though intensely hot in summer, is nevertheless remarkably healthy. This is no doubt a consequence of the extreme dryness of the atmosphere, occasioned by the absence of rain and the absorbent qualities of the soil. The upper regions of Nubia, however, are by no means destitute of rain, but are exposed from March to May to those showers which cause the overflowing of the Nile. They do not extend N. of 17. 30. N. Lat. The plague has seldom or never reached Wady Halfa, and beyond the Second Cataract it is entirely unknown. The small-pox, however, is a fearful scourge, and, owing to the ignorance and filthiness of the people, occasionally commits dreadful ravages.

Population.

The people are now generally known by the name of Nubians, and are called by the Arabs *Barabra*. They consist of the Kenoos and Nooba tribes, and differ considerably in appearance at different places, those to the south being much darker than the inhabitants of the country bordering on Egypt. They are generally well made, strong, and muscular, and have tolerably good features. The women are not handsome, but perfectly well formed, and in general remarkable for agreeable countenances and pleasing manners. Great numbers of the Nubians repair to Cairo, where they usually act as porters, and are esteemed for their honesty; but they always return to their native villages with the little property which they have saved in plying their humble vocation. They excel the Egyptians in honesty and veracity, though they are inferior in acuteness. They are likewise distinguished for their brave, independent, and patriotic spirit. The inhabitants of Derr-el-Mahas and the more southerly districts differ considerably from the other Nubian tribes. They are of Arab descent, and speak the language and follow the wandering life of that people.

Government and commerce.

Previously to 1821 the Nubians were independent, being ruled by chiefs of their own; but in that year they were brought under the power of the Egyptian pashas; and the government of Nubia is now, like that of Egypt, a military despotism. Some trade is carried on in Nubia, Sennaar and Shendy being the principal marts for the commerce of eastern Africa. The principal articles of export to Egypt are dates, which are obtained here of an excellent quality; gold, ivory, ebony, and slaves are imported into Nubia from the interior of Africa, and thence sent to Egypt, Arabia, or the East; and the principal imports through Egypt are soap, sugar, beads, coral, paper, and hardware.

One of the most remarkable features of this region consists in the magnificent monumental remains with which it

Nubia.

Monumental remains of Nubia.

is covered along the line of the stream, and which continue to perpetuate the genius and power of the ancient population of the country situated on the Upper Nile. The principal remains in Nubia, beginning with the lowest down on the river and proceeding upwards, are the following:—At Dabod on the W. bank, 15 miles above the First Cataract, are the remains of a temple, dedicated, according to a Greek inscription over the entrance, by Ptolemy Philometer and his queen Cleopatra, to Isis and other deities. The temple of Kalabshee, whose ruins stand on the same side of the Nile, about 29 miles above Dabod, is the largest in Nubia. It does not seem to be earlier than the time of Augustus, though the materials have apparently been taken from an older building. The body of the temple consists of three parts, and has twelve columns in front. It stands in the middle of an inclosure, which is entered by a portico with two pyramidal towers. At the same place is an ancient temple of the age of the Pharaohs, cut out of the rock, and adorned with elegant sculptures. The temple of Dendoor, which stands just within the tropic, is believed to have been founded by Augustus in honour of Osiris, Isis, and Horus. At Dakkeh, further up than Dendoor, are the remains of a temple founded by Ergamun, an Ethiopian king of the age of Ptolemy Philadelphus. On the opposite side there are extensive brick ruins, bearing the names of Remeses VII. and VIII., who lived in the twelfth century B.C. The ruined structure at Sabooa has before it a propylon, with two pyramidal towers. The pronaos on each of its longest sides has five columns without capitals, and in front of each is a colossal figure, 16 feet in height, with the arms crossed on the breast, and the usual emblems in the hands. In front of the propylon are two statues, 10 feet in height, with their faces towards the river, and attached by the backs to stone pillars of equal elevation: and an avenue of sixteen sphinxes leads from the bank of the Nile to the temple. The whole fabric appears to be of the remotest antiquity, and is ascribed to the age of Remeses the Great (1355–1289 B.C.) Of the same era is the temple of Derr, which, has some bold though defaced sculptures.

But of all the temples of Nubia, that of Aboo-Simbel Ebsamboul or Ipsamboul, about 40 miles below the Second Cataract, is incomparably the most remarkable. It has the finest colossal figures of any in Egypt, which, notwithstanding their great size, have countenances of considerable beauty, when seen from a proper distance. The great hall contains eight pillars with colossal figures attached to them, and there are many other apartments opening into it. Both the pillars and the walls are covered with representations of battles, storming of castles, triumphs, and sacrifices, in a style, if not superior to, at least bolder than, that of almost any in Egypt, both in regard to the design and the workmanship. The second hall, which is of less dimensions, contains four pillars about 4 feet square, and the walls are covered with hieroglyphics in tolerable preservation. Beyond this there is a chamber of the same width, but shorter, in which is the entrance to the sanctuary; and at each end is a door leading into smaller apartments in the same direction with the adytum. The sanctuary itself is 23 feet in length by 12 in breadth, and contains a pedestal in the centre, with four colossal figures in a sitting posture at the end, all in good order and uninjured. The outside or external front of this temple is truly magnificent, being 117 feet in width, and 86 feet in height, whilst the space from the top of the cornice to that of the door is 66½ feet, and the height of the door itself 20 feet. There are four enormous sitting figures, the largest in Nubia, or even in Egypt, excepting only the great sphinx at the Pyramids, to which they approach in the proportion of nearly two-thirds. On the top of the door is a statue of Osiris, 20 feet in height, with a colossal figure on each side looking towards it. The cornice of the temple is adorned with hieroglyphics, and under it are a torus and frieze, the one 6 and the other 4 feet in breadth. Above the cornice is a row of squatted monkeys, twenty in number, and each 8½ feet across the shoulders. This temple was nearly two-thirds buried in the sand till the year 1817, when the sand was cleared away, and an entrance obtained by Belzoni, Irby, Mangles, and Beechey. In several places of the square border which encircles the front of the temple, and also on the buttresses between the colossal figures, are a number of ovals or rings, containing the name and prænomen of Remeses the Great, the same Pharaoh whom the Greeks indicate by the name of Sesostris or Sethosis.

Nuddea.

The temples at Samneh, situated on the western bank of the river, between the twenty-first and twenty-second degree of north latitude, afford specimens of a more perfect class of structures; intermediate, it would seem, between such excavations as that of Ebsamboul and the magnificent edifices of Karnak and Luxor. That on the eastern bank has a portico and a hall running parallel to it, behind which are three small and one larger chamber; and that on the other side is more elegant, consisting of one chamber surrounded by a corridor of pillars.

General deductions.

The first architectural attempt in Nubia probably was the improvement of some hole or cave in the rock; or even if the country possessed no natural caves for imitation by a people possessing the troglodyte habits natural to the inhabitants of a burning climate, the mountains themselves would afford facilities for constructing durable habitations. After having got possession of a hole or cave, the next step of these primitive architects would probably be to extend the excavation, to form several chambers separated by the native rock, and when a compartment of larger dimensions was designed, to have square pillars for the support of the roof. In the course of time the outer front, with the inner walls and pillars, would receive decorations derived from imitations of the natural forms of the country, and subjects connected with the historical remembrances or religious creed of the nation. We see abundant evidence in the rock-temples of Nubia to convince us that the order of progression and improvement here indicated was that actually followed in their gradual enlargement and decoration; yet a prodigious period must have elapsed between the rudest excavation in the rock, such as Derr appears to have been in its primitive state, and the highly-finished sculptures of the great temple of Ebsamboul. In fact, "antiquity appears to have begun" long after these primeval architects had commenced their troglodyte labours. But, in surveying the wonders which crowd the banks of the Nile from Meroë to Memphis, our minds become insensibly impressed with the reflection, that the wealth, power, and genius which produced them have entirely passed away; that, if new worlds have risen, and new races been discovered, "we have lost old nations;" and that, in the lapse of ages, empires themselves vanish, like the baseless fabric of a vision, leaving scarcely a wreck or trace behind them. The contrast between what now is and what once must have been in Ethiopia and in Egypt, is indeed most striking; nor is it easy to pass, even in thought, through the various scenes of conquest and desolation which must have conspired to produce the effects we contemplate. History sheds no light on events and characters which the lapse of 3000 years has covered with impenetrable obscurity; and whilst groping our way amidst temples dedicated to gods, and structures raised in honour of heroes, whose very names sound like voices from the dead, we content ourselves with the conclusion, which all the monuments impress on us, that long before the dawn of history there had existed in that singular region a great people, whose architectural monuments have outlasted their learning, their philosophy, and almost even their very name.

NUDDEA, a district of British India, under the lieu-

Nuddea ‖ Numerianus.

tenant-governor of Bengal, comprised within the delta of the Ganges, and lying between Lat. 22. 49. and 24. 10. N., and Long. 88. 9. and 89. 11. E. It is about 90 miles in length from N. to S., by 45 in breadth, and has an area of 2942 square miles. The soil is well watered and highly fertile, producing in abundance rice, millet, maize, pulse, oil-seeds, sugar-cane, indigo, tobacco, and hemp. Pop. 298,736.

NUDDEA, a town of British India, in the district of Burdwan, at the commencement of the Hooghly River, 80 miles N. of Calcutta, Lat. 23. 25. N., Long. 88. 22. E. It was the capital of a Hindu principality anterior to the Mogul conquest of Hindustan, and was taken and entirely destroyed in 1204. In modern times it has been the seat of a Brahmin seminary of learning; anterior, however, to that of Benares.

NUGEENAH, a town of British India, division of Rohilcund, North-West Provinces, in Lat. 29. 27. N., Long. 78. 30. E. It is noted for its manufactures of fire-arms; and contains about 14,000 inhabitants.

NUISANCE, or NUSANCE, in law, a thing done to the annoyance of another. Nuisances are either public or private. A public or common nuisance is an offence against the public in general, either by doing what tends to the annoyance of all the king's subjects, or by neglecting to do what the common good requires; in which case, all annoyances and injuries to streets, highways, bridges, and large rivers, as also disorderly ale-houses, gaming-houses, and the like, are held to be common nuisances. A private nuisance is, when only one person or family is annoyed by the doing of anything; as when a person stops up the light of another's house, or builds in such a manner that the rain falls from his house upon his neighbour's. In Scotch law, there is no recognised distinction between public and private nuisances.

NUMA POMPILIUS, the successor of Romulus on the throne of Rome, was the son of an illustrious Sabine, and was raised to the imperial dignity by the unanimous voice of the Roman senate and people. After a remarkably popular reign of 42 years, during which he endeared himself both to his own people and to the surrounding nations by his great abilities and singular humanity, Numa died in the year of Rome 82. (See ROMAN HISTORY.)

NUMANTIA, a very noble city, the ornament of the Hither Spain, and celebrated for the long war of 20 years which it maintained against the Romans. The inhabitants obtained some advantage over the Roman forces, till Scipio Africanus was empowered to finish the war, and to effect the destruction of Numantia. The town occupied an eminence of great steepness, and was approachable only on one side. Scipio began the siege with an army of 60,000 men, and was bravely opposed by the besieged, who were no more than 4000 men able to bear arms. They held out against the enemy with the most indomitable courage while their provisions lasted; but being reduced to desperation, they set fire to their houses, and destroyed themselves, so that not even one remained to adorn the triumph of the conqueror. It was taken by the Romans 134 B.C., and the conqueror obtained the surname of *Numanticus*. It is conjectured that the modern Puente de Garray, near Soria, marks the site nearly of this once famous city. Fragments of antiquity are occasionally dug up there. (Accounts of this memorable siege are to be found in Appian, *B. Hisp.* 48, &c.; Eutropius, iv.; Cicero, *De Off.*; Strabo, iii.; also in the *Compendio Historiæ*, b. iii., of Pedro Tutor y Melo, Soria, 1690.)

NUMBERS, BOOK OF. See PENTATEUCH.

NUMERALS. See ARITHMETIC.

NUMERIANUS, MARCUS AURELIUS, a Roman emperor, succeeded to the purple conjointly with his elder brother Carinus, on the death of his father Carus, A.D. 284, and was murdered in the same year, after a reign of eight months. (See ROMAN HISTORY.)

Numidia.

NUMIDIA, an ancient country of Africa, which owed its name to the circumstance that its early inhabitants were pastoral tribes (Νομάδες). These tribes, differing both in descent and character, extended their wanderings from the Nile along the coast as far west as the Fortunate Islands. The limits of the country were therefore for a long time very ill-defined. It was not until the time of the Punic wars that the title of Numidians came to be definitely restricted to the Massæsyli and the Massyli, who dwelt between the River Mulucha (*Malouia*) on the W., and the Carthaginian territory on the E., and were divided from each other by the River Ampsaga (*Wad-el-Kebir*). These two tribes were then athletic and warlike savages, living on the sides of the mountains in little huts called *magalia*, and scouring the plains on horseback without saddle or bridle. From that period, however, the character of the people, and the condition of the country, began to be changed by foreign interference and the events of war. During the struggle between Hannibal and the Romans, Syphax, the prince of the Massæsyli, espoused the cause of the former, and Masinissa, the prince of the Massyli, espoused the cause of the latter. Syphax was defeated, along with his great ally, in the battle of Zama, B.C. 202; his territories were incorporated with those of the Massyli; all the Carthaginian district, with the exception of a portion around the capital city, was added; and Masinissa received possession of the whole, with the title of King of Numidia. It then became the aim of that able prince to civilize his people by the introduction of arts and agriculture. After his death in 148 B.C., the same line of policy was followed, with even more success, by his son and successor Micipsa. But the commotions that broke out in the ensuing reign marred the prosperity which a long peace had been fostering. Jugurtha, the nephew, and Adherbal and Hiempsal, the sons of Micipsa, were left joint-heirs to the throne. The first of these princes was unscrupulous and ambitious, and did not rest until he had defeated and murdered his cousins, and had seized the sceptre of the entire kingdom. This involved the Numidians in a contest with the Romans. After all the wiles of intrigue and the stratagems of war had proved unsuccessful, the usurper was captured and put to death in 106 B.C., and the crown was bestowed upon Hiempsal II. But the disasters of Numidia were not yet ended. Juba I., the son and successor of the last-mentioned prince, espoused the cause of Pompey during the Roman civil war. The final defeat of his party at the battle of Thapsus, in 46 B.C., left him exposed to the vengeance of Cæsar. The desperate state of his affairs drove him to commit suicide; and his kingdom, reduced into the form of a Roman province, was placed under the governorship of Sallust the historian. Soon after this period Numidia began to enter upon a long period of prosperity. The "jus coloniæ" was conferred upon its capital, Cirta (*Constantina*), and upon its other chief towns—Rusicade, Hippo-Regius (*Bona*), Sicca (*Keff*), Lambæsa, and Theveste. Commerce was diffused by means of the Roman roads; peace was preserved by means of the Roman soldiers; and the wild Numidian horsemen were thus transformed in course of time into a community of industrious peasants. The gospel found an easy entrance, and prospered so rapidly, that the country is said to have contained in the fifth century no fewer than 123 episcopal sees. It was not until the invasion of the Saracens, in the seventh century, that the prosperity of Numidia, simultaneously with its Christianity, received a fatal blow. (See ALGIERS. For further information regarding Numidian history, see also MASINISSA, MICIPSA, JUGURTHA, and JUBA I.)

NUMISMATICS.

INTRODUCTION.

Introduction.

Definition.

THE science of Numismatics treats of coins and medals.[1] It acquaints us with the metals used in their composition, their various inscriptions and devices, their mechanical execution and artistic merit. It tells us of the different denominations of coins, with their relation to one another, and the laws by which they were regulated.

Coins and medals.

The earliest known coins were issued by the Greeks, most probably in the eighth century before the Christian era.[2] By the fourth century the whole civilized world used money, each state generally having its proper coinage. This has continued to be the case to the present time; so that now there are few nations without a metal currency of their own, and of these but a small proportion are wholly unacquainted with the use of coins. The number of varieties of coins and medals of which specimens are preserved in collections may be estimated at not less than 200,000;[3] and future discoveries will probably greatly raise this sum. A series of monuments of such length and completeness affords, as might be expected, very important illustration to history and to kindred branches of knowledge. This is, indeed, the real value of Numismatics; and the student will do well to keep it constantly before him, for thus he will be saved from the narrow view of a mere collector, by which many have been led in a false direction, and so discredit has been brought upon the science.

How they illustrate history,

Coins, although they confirm history, rarely correct it, and never very greatly. The earliest belong to a time and to nations as to which we are not otherwise wholly ignorant, and they do not afford us that precise information that would fill in any important details of the meagre sketch of contemporary history. We gain from them scarcely any direct historical information, except that certain cities or princes issued money. When, in later times, the devices and inscriptions of the coins give more detailed information, history is far fuller and clearer, so that the numismatic evidence is rarely more than corroborative. There are, indeed, some remarkable exceptions to this rule, as in the case of the Bactrian coins, which have supplied the outlines of a portion of history which was otherwise almost wholly lost. The value of the corroborative evidence afforded by coins must not, however, be overlooked. It chiefly relates to chronology, although it also adds to our knowledge of the pedigrees of royal houses. But perhaps the most interesting manner in which coins and medals illustrate history is in their bearing contemporary, or nearly contemporary, portraits of the most famous kings and captains, from the time of the first successors of Alexander the Great to the present age: whereas pictures do not afford portraits in any number before the latter part of the middle ages; and works of sculpture, although occupying, in this respect, the same place as coins in the last-mentioned period and under the Roman empire, are neither so numerous nor so authentic. There is no more delightful companion in historical reading than a cabinet of coins and medals. When we know the features of Alexander and Mithradates, of Julius Cæsar and Augustus, of the Antonines and Severus, we can far more readily take ourselves back to the times in which they lived, and feel a real interest in their stories. Our belief in the truth of history is confirmed by the qualities we can perceive in their portraits. The strength and energy of Alexander, the brilliant genius of Mithradates, the philosophic calmness of Antoninus, the obstinate ferocity of Nero, and the brutality of Caracalla, are as plain on the coins as in the pages of history. The numismatic portraits of the time following the founding of Constantinople have less individuality; but after the revival of art they recover that quality, and maintain it to our own day, although executed in very different styles from those of antiquity. From this last class we can form a series of portraits more complete and not less interesting than that of the ancient period.

Introduction.

While coins and medals thus illustrate the events of history, they have an equally direct bearing on the belief of the nations by which they were issued; and in this reference lies no small part of their value in connection with history. The mythology of the Greeks not having been fixed in sacred writings, nor regulated by a dominant priesthood, but having grown out of the different beliefs of various tribes and isolated settlements, and having been allowed to form itself comparatively without check, can scarcely be learned from ancient books. Their writers give us but a partial or special view of it, while even modern authors, in their attempts to systematize, have often but increased confusion. The Greek coins, whether of kings or cities, until the death of Alexander, bear sacred subjects only. Afterwards, on the regal coins, the king's head usually occupies the obverse, and a sacred subject is placed on the reverse. About this period the local myths begin to lose their special character, through the destruction of the small independent states, and the centralized system of the great empire and the kingdoms which sprang from it. The earlier coins afford us invaluable evidence for the reconstruction of Greek mythology. We have nowhere else so complete a series of the different types under which the divinities were represented. There are in modern galleries very few statues of Greek divinities, including such as were intended for architectural decoration, which are in good style, fairly preserved, and untouched by modern restorers. If we add to these, bas-reliefs of the same class, and the best Græco-Roman copies, we can scarcely form a complete series of the various representations of these divinities. We cannot take ruder or baser works, since we should be led into error by them. The coins, however, supply us with the series we desire, and we may select types which are not merely of good work, but of the finest. The mythology of ancient Italy, as distinct from that of the Greek colonies, is not so fully illustrated by the coins of the country, because these are for the most part of Greek design. There are, however, some remarkable exceptions, especially in the money of the Roman commonwealth, the greater number of the types of which are of a local character, including many that refer to the myths and traditions of the earliest days of the city. The coins of the empire are especially important, as bearing representations of those personifications of an allegorical character to which the influence of philosophy gave great prominence in Roman mythology.

Mythology,

Geography,

Coins are scarcely less valuable in relation to geography than to history. The position of towns on the sea, or on rivers, the race of their inhabitants, and many similar particulars, are positively fixed on numismatic evidence. The information that coins convey as to the details of the history of towns and countries has a necessary connection with geography, as has also their illustration of local forms of worship. The representations of natural productions on ancient money are of special importance, and afford assistance to the lexicographer. This is particularly the case with the Greek coins, on which these objects are frequently portrayed with great fidelity. We must recollect, however, that the nomenclature of the ancients was vague, and frequently comprised very different objects under one appellation, and that therefore we may find very different representations corresponding to the same name.

Art,

The art of sculpture, of which coin-engraving is the offspring, receives the greatest illustration from Numismatics. Not alone is the memory of lost statues preserved to us in the designs of ancient coins, but those of Greece afford admirable examples of that skill by which her sculptors attained their great renown. The excellence of the designs of very many Greek coins struck during the period of the best art is indeed so great, that, were it not for their smallness, they would form the finest series of art-studies in the world. The Roman coins, though at no time to be compared

[1] This science cannot be considered to be a branch of Archæology, since it treats not only of ancient and mediæval coins, but of modern ones also.

[2] The Chinese place the commencement of their coinage at a very remote date, but this statement is unsupported by satisfactory evidence. All authentic specimens appear to be several hundred years later than the oldest Greek money. (See sect. vi., below.)

[3] The collection of the British Museum now comprises upwards of 120,000 specimens; and during late years from 2000 to 5000 pieces have been annually added.

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to the purest Greek, yet represent worthily the Græco-Roman art of the empire. From the accession of Augustus to the death of Commodus they are often fully equal to the best Græco-Roman statues. This may be said, for instance, of the dupondii struck in honour of Livia by Tiberius, and by the younger Drusus; of the sestertii of Agrippina; and of the gold coins of Antoninus Pius and the two Faustinas, which present portraits of remarkable beauty and excellence. The mediæval Italian medals are scarcely less useful as records of the progress and characteristics of art, and, placed by the side of the Greek and Roman coins, complete the most remarkable comparative series of monuments illustrating the history of the great schools of art that can be brought together. Ancient coins throw as great light upon the architecture as upon the sculpture of the nations by which they were struck. Under the empire, the Roman coins issued at the city very frequently bear representations of important edifices. The Greek-imperial coins, struck in the provinces, present similar types representing the most famous temples and other structures of their cities, of the form of some of which we should otherwise have been wholly ignorant. The little-known art of painting among the ancients does not receive any great illustration from the coins. The best Greek pieces are of too severe a style to admit of an approach to pictorial treatment, although we perceive such a tendency in the works of important schools, and during the period of decline. The Roman coins sometimes present groups which have a very pictorial character, traceable to the tendency of the sculpture of the period: this is principally about the time of the Antonines. They are never, however, so pictorial in treatment as the mediæval Italian medals. The art of gem-engraving among the ancients is perhaps most nearly connected with their coinage. The subjects of coins and gems are so similar and so similarly treated, that the authenticity of gems, that most difficult of archæological questions, receives the greatest aid from the study of coins. No one whose eye is acquainted with the treatment of figures by Greek and Roman medallists could suppose for a moment such works as those of the Poniatowski collection to be productions of ancient artists. It is probable, also, that coins not unfrequently supplied subjects to the old gem-engravers.

Literature.

After what has been said, it is not necessary to do more than mention how greatly the study of coins tends to illustrate the contemporary literature of the nations which issued them. Not alone the historians, but the philosophers, and the poets are constantly illustrated by the money of their times. This was perceived at the revival of letters; and during the last two centuries coins were very frequently engraved in the larger editions of the classics. A want of technical numismatic knowledge in the editors, and the carelessness of the artists, combined to deprive these illustrations of much of their value. Probably in part on this account, but chiefly in consequence of the change from historical to textual criticism, ancient coins have been little used in this manner by the new school. This neglect is beginning to be remedied, although the full value of coins and medals in illustration of the literature of modern as well as ancient times is not as yet sufficiently perceived.

Origin of this science.

The science of Numismatics is of a comparatively recent origin. The ancients do not seem to have formed collections, although they appear to have occasionally preserved individual specimens for their beauty. Petrarch has the credit of having been the first collector; but it is probable that in his time ancient coins were already attracting considerable notice. The importance of the study of all coins has since been by degrees more and more recognised; so that at the present time no branch of the pursuit is left wholly unexplored. It cannot, however, be said that the actual condition of the science justifies great expectations. We shall best perceive this if we inquire what objects it has to fulfil.

Definitions.

Its uses.

Besides its bearing upon the history, the religion, the manners, and the arts of the nations which have used money, the science of Numismatics has, from its relation to art, a special modern use, at which we have already hinted. Not alone do coins display the various styles of art prevalent at different ages, but in doing so they supply us with abundant means for promoting the advancement of art among ourselves. If the study of many schools be at all times of advantage, it is especially so when there is little originality in the world. Coins and medals have therefore two main uses, the one relating to the illustration of history, and the other to the promotion of art. It is not for these purposes that collections are usually formed. It is in vain to point to the high prices now paid for rare coins, if that rarity be not always accompanied by some marked historical or artistic importance. Very few among the collectors think of any thing beyond the rarity or the beauty of a coin, and of the latter they frequently judge by a vicious standard. So little have the coins themselves been thoroughly studied even by professed numismatists, that few of them have formed an opinion as to the different denominations to which many of the most common specimens correspond. The study of ancient coins, and that of ancient systems of coinage, have been more and more separated. There is also much reason to complain of the comparative neglect of various branches of Numismatics. Until equal attention be paid to all, the condition of the science cannot be called sound. Why, for instance, while the Roman money is eagerly collected and studied, is the Byzantine series, its proper continuation, and one of the most important portions of the mediæval class, generally treated with contemptuous neglect? Numismatics, thus superficially and partially pursued, demands the least labour and affords no result of importance, except the negative one of bringing into disrepute one of the most valuable aids to historical inquiry.

Sect. I.—DEFINITIONS.

The following are the most necessary numismatic definitions:—

1. A *coin* is a piece of metal of a fixed weight, stamped by authority of government, and employed as a circulating medium.[1]

2. A *medal* is a piece struck to commemorate some event or person, and having no place in the currency. Medals are frequently comprised with coins in descriptions that apply to both equally: thus, in the subsequent definitions, by the term coins, coins and medals must generally be understood.

3. The coinage of a country is usually divided into the classes of gold, silver, and copper, for which the abbreviations *A*, *AR*, and *Æ*, are employed in catalogues. In each class are comprised not only the coins of the metal from which it takes its name, with no more than a necessary or inseparable proportion of alloy, but coins of other metallic substances, usually base, and always compound, which were generally struck in the place of the purer pieces. The principal metallic substances thus used were electrum for gold, billon for silver, brass for copper, and potin for silver and copper.

4. *Electrum* (ἤλεκτρον, ἤλεκτρος), a compound metallic substance, consisting of gold with a considerable alloy of silver. Pliny makes the proportion to have been four parts of gold to one of silver.[2] The material of early coins of Asia Minor struck in the cities of the western coast is the ancient electrum. It appears here to have first consisted of three parts of gold to one of silver; but afterwards the proportion of silver was increased, though perhaps not everywhere. Gold largely alloyed with silver, not struck by the ancient Greeks

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[1] This definition excludes, on the one hand, paper currencies and their equivalents among barbarous nations, such as cowries, because they are neither of metal nor of fixed weight, although either stamped or sanctioned by authority, and, on the other hand, modes of keeping metal in weight, like the so-called Celtic "ring-money," as not stamped, although perhaps sanctioned by authority. The latter has attracted so much attention, that it must not be passed by without some further notice. There seems to be no reasonable doubt that the Celtic gold rings all weigh multiples of the same unit, but very seldom multiples of one another. From their form, it is probable that most of them were used as ornaments, and as such they would probably have been generally made to weigh an exact weight without fractions, on the same principle that the ancients frequently avoided fractions of their measures in architecture. They belong to a time anterior to the introduction of money among the Celts, or before its general use, and one, therefore, at which precious metal must have been weighed when employed in barter. Hence an additional reason, and probably the main one, why their weight is always some multiple of the same unit. In a primitive state of society in the present day, a woman often wears her dowry in coins as ornaments; and thus these Celtic rings may have been both ornaments and substitutes for money.

[2] *Hist. Nat.* xxxiii. 23; comp. xxxvii. 11. Pliny distinguishes two kinds of "electron," amber, and this metallic substance. In Greek poetry the name seems to apply to both, but it is generally difficult to decide which is meant in any particular case. Sophocles, however, where he mentions τὸν πρὸς Σάρδιων Ἤλεκτρον, ... καὶ τὸν Ἰνδικὸν Χρυσόν (*Ant.* 1037-1039), can scarcely be doubted to refer to the metallic electrum.

Definitions.

or their neighbours, should be termed *pale gold*, as in the case of some of the late Byzantine coins.

5. *Billon*, a term applied to the base metal of some Roman coins, and also to that of some mediæval and modern coins. It is silver with a great proportion of alloy. When the base silver coins are replaced by copper washed with silver, the term billon becomes inappropriate.

6. *Brass*, a compound metallic substance employed for coins. It may be used as an equivalent to the orichalcum of the Romans, a fine kind of brass, of which the sestertii and dupondii were struck, but it is commonly applied indiscriminately to the whole of their copper currency.

7. *Potin*, a term applied to the base metal of which some ancient coins are composed. It is softer than billon.

8. Various other metallic substances have been used in coinage. The so-called "glass money" of the Arabs has not been proved to have borne any value, and if it had, it would be excluded with paper money and the like from the class of coins.

9. The *forms* of coins have greatly varied in different countries and at different periods. The usual form in both ancient and modern times has been circular, and generally of no great thickness.

10. Coins are usually measured by *Mionnet's scale*, from which the greatest dimension is taken, or when they are square, the greatest dimension in two directions. This is, however, a very unsatisfactory scale, as its divisions are of an arbitrary character, and the instruments for applying it are such as make exactness scarcely possible. A kind of gauge, graduated to inches and decimal parts of an inch, would be far more satisfactory.

11. The *weight* of a coin is of great importance, both in determining its genuineness and in distinguishing its identity. To ascertain exact weight to the tenth of a grain is therefore very necessary, and this can only be done by the careful use of excellent scales.

12. The *specific gravity* of a coin furnishes a ready means of determining the metal predominating in its composition.

13. Whatever representations or characters are borne by a coin constitute its *type*. The subject of each side is also called a type, and when there is not only a device but an inscription, the latter may be excluded from the term. This last is the general use. No distinct rule has been laid down as to what makes a difference of type, but it may be considered to be an essential difference, however slight.

14. A difference too small to constitute a new type makes a *variety*.

15. A coin is a *duplicate* of another when it agrees with it in all particulars but those of exact size and weight. Strictly speaking, ancient coins are rarely, if ever, duplicates, except when struck from the same die.

16. Of the two sides of a coin, that is called the *obverse* which bears the more important device or inscription. In early Greek coins, it is the convex side; in Greek and Roman imperial, it is the side bearing the head; in mediæval and modern, that bearing the royal effigy, or the king's name, or the name of the city; and in oriental, that on which the inscription commences. The other side is called the *reverse*.

17. The *field* of a coin is the space unoccupied by the principal devices or inscriptions. Any detached independent device or character is said to be in the field, except when it occupies the exergue.

18. The *exergue* is that part of the reverse of a coin which is below the main device, and distinctly separated from it: it often bears a secondary inscription. Thus, the well-known inscription CONOB occupies the exergue of the late Roman and early Byzantine gold coins.

19. The *edge* of a coin is the surface of its thickness.

20. By the *inscription* or *inscriptions* of a coin, all the letters it bears are intended: an inscription is either principal or secondary.

21. In describing coins, the terms *right* and *left* mean the right and left of the spectator, not the heraldic and military right and left, or those of the coin.

22. A *bust* is the representation of the head and neck: it is commonly used of such as show at least the collar-bone, other busts being called heads.

23. A *head* properly means the representation of a head alone, without any part of the neck, but it is also commonly used when any part of the neck above the collar-bone is shown. In the present article we have followed custom in the use of the terms *bust* and *head*.

24. A bust or head is either facing or in profile, in which latter case it is described as *to right* or *to left*. Two busts may be placed in various relative positions which cannot be described in English without circumlocution.

25. A bust wearing a laurel-wreath is said to be *laureate*.

26. A bust bound with a fillet is described as *with a fillet*. The term *diademed* is scarcely permissible.

27. A bust of which the neck is clothed is said to be *draped*.

28. An object in the field of a coin which is neither a letter nor a monogram is usually called a *symbol*. This term is, however, only applicable when such an object is evidently the badge of a town or individual. The term *adjunct*, which is sometimes employed instead of symbol, is manifestly incorrect.

Arrangement of Coins.

29. A *mint-mark* is a difference placed by the authorities of the mint upon all money struck by them, or upon each new die or separate issue. This term is properly used only with reference to some mediæval and modern coins, since the mint-marks of ancient and oriental coins cannot be discriminated with any certainty.

30. A coin is said to be a *surfrappe* when it has been struck on an older coin, of which the types are not altogether obliterated.

31. A *double-struck* coin is one in which the die or dies have shifted so as to cause a double impression.

32. A coin which presents two obverse types, or two reverse types, or of which the types of the obverse and reverse do not correspond, is called a *mule*: it is the result of either a mistake or a caprice.

Sect. II.—ARRANGEMENT OF COINS.

No uniform system has as yet been applied to the arrangement of all coins. It is usual to separate them into the three great classes of ancient coins, comprising Greek and Roman; of mediæval and modern coins; and of oriental coins. The details of these classes have been differently treated, both generally and specially. The arrangement of the Greek series has been first geographical, under countries and towns, and then chronological, for a further division; that of the Roman series, chronological, without reference to geography; that of the mediæval and modern, the same as the Greek; and that of the oriental, like the Roman,—a treatment inadmissible except in the case of a single empire. Then, again, some numismatists have separated each denomination or each metal, or have separated the denominations of one metal and not of another. There has been no general and comprehensive system, constructed upon reasonable principles, and applicable to every branch of this complicated science. Without laying down a system of rules, or criticising former modes of arrangement, we offer the following as a classification which is uniform without being servile:—

1. *Greek Coins.*—All coins of Greeks, or barbarians who adopted their money, struck before the Roman rule, or under it, but without imperial effigies. The countries and their provinces are placed in a geographical order, from west to east, according to the system of Eckhel, with the cities in alphabetical order under the provinces, and the kings in chronological order. The civic coins usually precede the regal, as more important. The coins are further arranged chronologically, the civic commencing with the oldest, and ending with those bearing the effigies of Roman emperors. The gold coins of each period take precedence of the silver, and the silver of the copper. The larger denominations in each metal are placed before the smaller. Coins of the same denomination and period are arranged in the alphabetical order of the magistrates' names, or letters, &c., that they bear.

2. *Roman Coins.*—All coins issued by the Roman commonwealth and empire, whether struck at Rome or in the provinces, provided in the latter case that they are absolutely of the same character as the coinage of the city. The oldest proper Roman money is placed first, chronologically arranged; then that of the commonwealth, bearing the names of those who had the privilege of striking it, coins of all metals and denominations being placed under each family, and the families being put in alphabetical order; and, lastly, the coinage of each emperor, disposed either chronologically or geographically, according to the indications it offers, and without separation of denominations. An alphabetical arrangement of inscriptions must be resorted to in the family series and the imperial, when no other method can be followed, and in the smallest subdivisions, such as the coinage of one denomination issued in a particular year or by a particular mint.

3. *Mediæval and Modern Coins of Europe.*—All coins issued by European states, their branches and colonies, from the fall of the Empire of the West to the present day. This class is arranged in a geographical and chronological order, as similar as possible to that of the Greek class, with the important exception of the Byzantine coins and the coins following Byzantine systems, which occupy the first place. The reason for this deviation is, that the Byzantine money may be regarded not alone as the principal source of mediæval

Greek Coins.

coinage, but as the most complete and important mediæval series, extending as it does without a break throughout the middle ages. The regal coins usually precede the civic ones, as more important; and the medals of each sovereign or city follow the coins. The money of the Turkish empire is included in the oriental class.

4. *Oriental Coins.*—All coins bearing inscriptions in eastern languages, excepting those of the Jews, Phœnicians, and Carthaginians, which are classed with the Greek coins, from their close connection with them. These coins should be arranged under two great divisions, Pagan and Mohammadan,—the one nearly corresponding to the Greek and Roman class, the other to the mediæval and modern; for although the former includes modern coins, they are essentially similar to those of the ancient period. The first division is arranged for the most part according to the same general principles as the Greek series, the kingdoms being disposed geographically, and their sovereigns in a chronological order. It commences with the coinage of the Persian empire, and ends with that of China. The second division follows in general the same method of arrangement, with one important deviation, that the coins of the Umawee and Abbásee Khaleefehs occupy the first place.

This method of arrangement will be found to be as uniform as it can be made, without being absolutely mechanical and servile. It differs in some important particulars from most or all of those which have previously obtained; but these very differences are the result of the consideration of a complete collection, and have therefore an inductive origin. A general uniformity is no slight gain, and may well reconcile us to some partial defects. These defects may be remedied in large collections by the use of "cross-references" from one cabinet to another, and by the formation of independent series to illustrate the general one. The latter suggestion is one that is well worthy careful consideration. A series illustrative of Greek art, and another of Roman art, might be formed. A series of portraits, and another of groups, would be equally valuable. Others might be made to show the changes of the coinage in relation to the condition of a state, with careful indications of the weight and composition of the examples, and to illustrate the history of a particular country or city. Thus, the Byzantine copper coinage exhibits the success or disaster of the imperial arms, and the financial state of the empire, in its fluctuations; while nothing can be more interesting than to see at one view the numismatic history of a great city. We have coins of Rome under the commonwealth and the empire, under the Ostrogoths, the Byzantines, the senate, and the popes. The series of London would be not the least curious. It would begin with the Roman coins issued by the mint of Londinium at the time of Diocletian and his colleagues, comprising those of the usurpers Carausius and Allectus; then, having ceased not long after for a time, it would recommence with the Saxon pennies, including a specimen of those of King Alfred, which have for their reverse type the monogram of the city's name; and, continuing through the mediæval period, it would conclude with modern tokens and medals, among the latter of which might be placed a copy of that famous one of the first Napoleon, with the inscription "Frappée à Londres," which was intended to commemorate the success of the Boulogne expedition.

Sect. III.—GREEK COINS.

There are some matters relating to Greek coins in general which may be properly considered before they are described in geographical order. These are their general character, their devices and inscriptions, the art of such as are not barbarous, the mode of striking, and the chief denominations, with the different talents of which they were the divisions.

General character.

The period during which Greek coins were issued was probably not less than a thousand years in length, commencing about the middle of the eighth century B.C.,[1] and generally ending at the death of Gallienus, A.D. 268. If classed with reference only to their form, fabric, and general appearance, they are of three principal types,—the archaic Greek, the ordinary Greek, and the Græco-Roman. The coins of the first class are of silver, of electrum, and sometimes of gold. They are thick lumps of an irregular round form, bearing on the obverse a device, with, in some cases, an accompanying inscription; and on the reverse a square or oblong incuse stamp (*quadratum incusum*), usually divided in a rude manner. The coins of the second class are of gold, electrum, silver, and copper. They are much thinner than those of the preceding class, and usually have a convex obverse, and slightly concave or flat reverse. The obverse ordinarily bears a head in bold relief. The coins of the third class are, with very few exceptions, of copper. They are flat and broad, but thin, and generally have on the obverse the portrait of a Roman emperor. It may be observed that the common division of Greek coins is into autonomous and imperial, the former comprising all except those of the Roman period which have the effigies of emperors.

Greek Coins.

In choosing the types of Greek coins (using the term in its restricted sense), the first intention was, that they should indicate the city or state by which the money was issued. The necessity for distinctive devices was most strongly felt in the earlier days of the art, when the obverse of a coin alone bore a design, and, if any inscription, but the first letter, or the first few letters, of the name of the people by which it was issued. The motive which dictated the kind of type to be selected was undoubtedly a religious one. This position has been established in a conclusive manner by Mr Burgon in his *Inquiry into the Motive which influenced the Ancients in their Choice of the Various Representations which we find stamped on their Money.*[2] There are some isolated instances in which the religious character of a type is doubtful; but these, if proved, would be only exceptions to a general rule. The piety of that age adopted religious devices, and for a long time it was held to be impious to substitute any other representations for them. To the same cause may, perhaps, be partly ascribed the preference on the most ancient coins for devices of a symbolical character to actual representations of divinities; although the difficulty of portraying the human form in the infancy of art must have had considerable influence in this direction.

Devices.

Greek coins, if arranged according to their types, fall into three classes,—1. Civic coins and regal, without portraits of sovereigns; 2. Regal coins bearing portraits; and, 3. Græco-Roman coins, whether with imperial heads or not. The coins of the first class have either a device on the obverse, and the *quadratum incusum* on the reverse, or two devices; and these last are again either independent of each other, though connected by being both local, or—and this is more common—that on the reverse is a kind of complement of that on the obverse. It will be best first to describe the character of the principal kinds of types of the first class, and then to notice their relation. It must be noted that a head or bust is usually an obverse type, and a figure or group a reverse one; and that, when there is a head on both obverse and reverse, that on the former is usually larger than the other, and represents the personage locally considered to be the more important of the two. We must constantly bear in mind that these types are local and religious, if we would understand their meaning. An observation of Mr Burgon, in the essay to which reference has just been made, puts this in a very clear light. "I do not believe," he says, "that the types of coins are, on any occasion, original compositions, but always copied (from the earliest to the lowest times) from some sacred public monument. Thus, when we find what is called a Bœotian buckler on coins, we are not to look upon the representation as *a Bœotian buckler*, but as *the buckler* of some Bœotian hero well known to the ancient inhabitants of that country, and accounted to be sacred by them. In like manner, when we find Minerva represented on coins, we are not to understand the type as *a Minerva*, but *the Minerva of that place*; and, in some cases which might be brought forward, the individual statues which are represented on coins, or ancient copies, will be found to exist. The only example of originality of composition apparent on coins is where types have been *doubled* or *halved*, to express similar modifications of value."[3]

Classification of devices.

[1] It is extremely difficult to fix the age of the earliest coins known to us; but on the whole it seems most reasonable to assume for them the approximative date we have given. They may be somewhat older, but it is scarcely possible that they can be much later.

[2] *Numismatic Journal*, vol. i., p. 97, *et segg.*

[3] *Id.*, note 70, pp. 115, 116. The doubling of a type is also indicative of two sovereigns reigning together, or of a king and his queen, examples of both of which cases occur on the Ptolemaic coins.

Greek Coins.

In the following list we have classified the types of Greek coins of cities, and of kings, not having regal portraits, in a systematic order, without referring to their relative antiquity :—

Coins without regal portraits.

1. Head or figure of a divinity worshipped at the town, or by the people, which issued the coin,—as the head of Pallas on coins of Athens, and the figure of Hercules on coins of Bœotian Thebes. Groups are very rare until the period of Græco-Roman coinage.

2. Sacred natural or artificial objects.
   - *a.* Animal sacred to a divinity of the place,—as the owl (Athens), and the tortoise (Ægina).
   - *b.* Sacred tree or plant,—as the silphium (Cyrene), and the olive-branch (Athens).
   - *c.* Arms or implements of divinities,—as the arms of Hercules (Erythræ), the tongs of Vulcan (Æsernia).

It is difficult to connect many objects comprised in this class with local divinities. The reason of this appears to be, that the Hellenes, wherever they colonized, and nowhere more than in Greece, found an earlier system of low Nature-worship, and endeavoured to incorporate it into their own more intellectual mythology, sometimes with but partial success.

3. Head or figure of a local genius.
   - *a.* River-god,—as the Gelas (Gela).[1]
   - *b.* Nymph of a lake,—as Camarina (Camarina).
   - *c.* Nymph of a fountain,—as Arethusa (Syracuse).

4. Head or figure of a fabulous personage, or half-human monster,—as Medusa (Neapolis Macedoniæ), the Minotaur (Cnossus).

5. Fabulous animal,—as Pegasus (Corinth), a gryphon (Panticapæum), the Chimæra (Sicyon).

6. Head or figure of a hero or founder,—as Ulysses (Ithaca); the Lesser Ajax (Locri Opuntii); Taras, founder of Tarentum (Tarentum).

7. Objects connected with heroes.
   - Animal connected with local hero,—as Calydonian boar or its jaw-bone (Ætolians). Arms of heroes also occur as types, but their attribution to particular personages is difficult or impossible.

8. Celebrated real or traditional sacred localities,—as a mountain or hillock (Apollonia Illyrici), the Labyrinth (Cnossus).

9. Representations connected with the public religious festivals and contests,—as a chariot victorious at the Olympic games (Syracuse).

The relation of the types of the obverse and reverse of a coin is a matter requiring careful consideration, since they frequently illustrate one another. As we have before observed, this relation is either that of two independent objects, which are connected only by their reference to the same place, or the one is a kind of complement of the other. Among coins illustrating the former class we may instance the beautiful silver didrachms of Camarina, having on the obverse the head of the river-god Hipparis, and on the reverse the nymph of the lake carried over its waters by a swan; and those of Sicyon, having on the obverse the Chimæra, and on the reverse a dove. The latter class is capable of being separated into several divisions. When the head of a divinity occurs on the obverse of a coin, the reverse is occupied by an object or objects sacred to that divinity. Thus the common Athenian tetradrachms have on the one side the head of Pallas, and on the other an owl and an olive-branch; the tetradrachms of the Chalcidians in Macedonia have the head of Apollo and the lyre; and the copper coins of Erythræ have the head of Hercules and his weapons. The same is the case with subjects relating to the heroes: thus there are drachms of the Ætolians which have on the obverse the head of Atalanta, and on the reverse the Calydonian boar, or its jaw-bone and the spear-head with which it was killed. In the same manner the coins of Cnossus with the Minotaur on the obverse, have on the reverse a plan of the Labyrinth. Besides the two principal devices, there are often others of less importance, which, although always sacred, and sometimes symbols of local divinities, are generally indicative of the position of the towns, or have some reference to the families of the magistrates who used them as badges. Thus, for example, besides such representations as the olive-branch, sacred to Pallas, on the Athenian tetradrachms, as a kind of second device dolphins are frequently seen on coins of maritime places; and almost every series exhibits many symbols which can only be the badges of the magistrates with whose names they occur. Regal coins of this class are usually of a local character, owing to the small extent of most of the kingdoms, which were rather the territories of a city than considerable states at the period when they were issued.

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Coins with regal portraits.

The second great class—that of coins of kings bearing portraits—is necessarily separate from the first. Religious feeling affords the clue to the long exclusion of regal portraits. It was not the result of that native horror of despotic power which made the early Greek kings or tyrants, from necessity or through policy, ape the character of citizens; but it was owing to a yet stronger feeling—the belief that it would be profane for a mortal to take a place always assigned hitherto to the immortals. Were there any doubt, it would be removed by the character of the earliest Greek regal portrait, that of Alexander, which occurs on coins of Lysimachus. This is not the representation of a living personage, but of one who was not alone dead, but had received a kind of apotheosis, and who having been already called the son of Jupiter Ammon while living, had been treated as a divinity after his death. He is therefore portrayed as a young Jupiter Ammon. Probably, however, he would not have been able, even when dead, thus to usurp the place of a divinity upon the coins, had not the Greeks become accustomed to the oriental "worship" of the sovereign which he adopted. This innovation rapidly produced a complete change; and every king of the houses which were raised on the ruins of the Greek empire could place his portrait on the money which he issued, and few neglected to do so, while the sovereigns of Egypt and Syria even assumed divine titles.

The reign of Alexander produced another great change in Greek coinage, very different from that we have noticed. He suppressed the local types almost throughout his empire, and compelled the towns to issue his own money, with some slight difference for mutual distinction. His successors followed the same policy; and thus the coins of this period have a new character. The obverses of regal coins with portraits have the head of the sovereign, which in some few instances gives place to that of his own or his country's tutelary divinity; while figures of the latter sort almost exclusively occupy the reverses. Small symbols on the reverses distinguish the towns in this class.

Græco-Roman coins.

The Græco-Roman coins commence, at different periods, with the seizure by Rome of the territories of the Greek states. They are almost all copper; and those in that metal are the most characteristic and important. In their types we see a further departure from the original religious intention of those of earlier times, in the admission of representations not alone of eminent persons who had received some kind of apotheosis, such as great poets, but also of others, who, although famous, were not, and in some cases probably could not have been, so honoured. We also observe on such of these coins as are Greek imperial many Roman types of an

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[1] The head of a river-god, supposed to be the Achelous, is represented on coins of Œniadæ as that of a bearded man covered with the skin of the head and neck of a bull. Col. Leake (*Numismata Hellenica*, Eur. Greece, pp. 79, 80) notices how this illustrates a passage in the *Trachiniæ* of Sophocles, where Dejanira describes the forms under which the Achelous appeared as her suitor.

"Μνηστὴρ γὰρ ἦν μοι ποταμὸς, Ἀχελῶον λέγω,
Ὃς μ' ἐν τρισὶν μορφαῖσιν ἐξήτει πατρὸς,
Φοιτῶν ἐναργὴς ταῦρος, ἄλλοτ' αἰόλος
Δράκων ἑλικτὸς, ἄλλοτ' ἀνδρείῳ κύτει
Βούπρῳρος· ἐκ δὲ δασκίου γενειάδος
Κρουνοὶ διεῤῥαίνοντο κρηναίου ποτοῦ." (9–14.)

The scholiast alludes to a passage in the description of the contest of Achilles with the rivers, in the *Iliad*, where the Scamander throws forth the slain, bellowing like a bull, *μεμυκὼς ἠΰτε ταῦρος* (xxi. 237.) The whole is very illustrative of the feeling which gave rise to the representations of vases and coins. Homer stands before the period of these designs, whereas the tragedians lived long after its commencement. He is original, while they may but reflect in their writings the subjects which they saw everywhere portrayed. It may be observed, that the first and third forms of the Achelous mentioned by Sophocles occur as those of rivers on vases and coins, besides that the third is varied by being represented without a beard, and that the second is found on vases, as that of the Achelous. A bull is the most common symbolical form of a river on the coins.

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allegorical character. The following principal kinds of types may be specified, in addition to those of the two previous classes:—

1. Head or figure of a famous personage who either had received a kind of apotheosis, as Homer (Smyrna), or had not been so honoured, as Herodotus (Halicarnassus), and Lais (Corinth).

2. Pictorial representations, always of a sacred character, although occasionally bordering on caricature. We may instance, as of the latter sort, a very remarkable type representing Pallas playing on the double pipe, and seeing her distorted face reflected in the water, while Marsyas gazes at her from a rock,—a subject illustrating the myth of the invention of that instrument (Apamea Phrygiæ).

3. Allegorical Roman types, as Hope, &c., on the coins of Alexandria of Egypt, and many other towns. These were of Greek origin, and owed their popularity to the sculpture executed by Greeks under the empire; but the feeling which rendered such subjects prominent was not that of true Greek art, and they are essentially characteristic of the lower school, which attained its best condition at Rome under the early emperors. Of this sort of type we must again speak in noticing the Roman coinage.

Those kinds of types which were common to this and the older classes were also considerably developed in their subjects. Thus, for instance, groups frequently took the place of single figures; and the representations of sacred localities acquired a great prominence—the most common being of buildings, which are generally temples. In the architectural types, a tendency to pictorial representation is evident in the constant endeavours to depict edifices in perspective.

Roman colonial coins.

There is a class of coins which is always considered as part of the Greek imperial, or Græco-Roman with imperial effigies, although in many respects distinct. This is the colonial series, struck in Roman coloniæ, and having almost always Latin inscriptions. As, however, these coloniæ were towns in all parts of the empire, from Emerita in Spain (*Merida*) to Niniva Claudiopolis (*Nineveh*) in Assyria, in the midst of a Greek population, and often of Greek origin, their coins help to complete the series of civic money, and, as we might expect, do not very markedly differ from the proper Greek imperial coins, except in having Latin inscriptions, and showing a preference for Roman types.

Inscriptions.

We have now to speak of the meaning of the inscriptions of Greek coins. These are either principal or secondary; but the former are always intended when inscriptions are mentioned without qualification, since the secondary ones are non-essential. The inscription of civic money is almost always the name of the people by which it was issued, in the genitive plural, as ΑΘΗΝΑΙΩΝ, on coins of the Athenians; ΣΥΡΑΚΟΣΙΩΝ, or coins of the Syracusans. The inscription of regal money is the name or name and title of the sovereign in the genitive, as ΑΛΕΞΑΝΔΡΟΥ, or ΒΑΣΙΛΕΩΣ ΑΛΕΞΑΝΔΡΟΥ, on coins of Alexander the Great. It has been hitherto always supposed that the word understood is "money" (*νόμισμα*); so that the inscriptions were read "money of the Syracusans," "money of Alexander," &c. Mr Burgon has, however, formed a different opinion; and although he has not yet made public the results of his inquiry, he has very generously communicated them to us, with permission to use them, without of course entering into details. He supposes the inscription to relate to the type, and that the word understood is the name of that type. It should be remarked that the type of the reverse of a coin being usually a complement of that of the obverse, there is in general virtually but one type—that of a tutelary divinity of the place or sovereign. The Athenian coins we have mentioned with the inscription ΑΘΗΝΑΙΩΝ have the type of a head of Pallas; and the meaning is therefore, according to Mr Burgon's explanation, not "the money of the Athenians," but "Pallas of the Athenians." When the name of the divinity represented is written, the word understood is supplied. Thus on coins of Syracuse, with the head of Arethusa as the type, we read ΑΡΕΘΟΣΑ—ΣΥΡΑΚΟΣΙΩΝ; and on others, with the head of Jupiter, ΖΕΥΣ ΕΛΕΥΘΕΡΙΟΣ—ΣΥΡΑΚΟΣΙΩΝ. We should not be justified in further discussing this explanation; but we must add, that its fitness to all inscriptions, and its congruity with the religious meaning of the types, as first discovered by Mr Burgon, afford the best arguments for its correctness. The secondary inscriptions either describe secondary types, as ΑΘΛΑ, accompanying the representation of the arms given to the victor in the exergues of Syracusan decadrachms; or are the names of magistrates or other officers; or, in regal coins, those of cities, or those of the engravers of the dies, of whom sometimes two were employed, one for the obverse, and the other for the reverse; or are dates. These inscriptions are often but abbreviations or monograms, especially when they indicate cities on the regal coins.

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Art of coins.

The importance of Greek coins as illustrating the character of contemporary art cannot be easily overrated. We would here speak of them in this relation in a general sense, without inquiring as to their bearing on particular branches of art. We would endeavour to assign them their true place as records of art, rather than to discuss their illustration of kindred monuments. It is indeed most desirable that something of this kind should be attempted. The question that is here proposed has not received a proper consideration; and the partialities of a period of bad taste, themselves founded on partly spurious merits, have been handed down as traditions not to be questioned to those who receive with too blind a reverence all the productions of Greek art. Not alone discriminating praise, but the most jealous observation of faults, characterizes the highest kind of regard. All human art must be faulty; and blind admiration indicates nothing better than a weak judgment. The Greek artists, indeed, by making beauty the first quality in art, and by forming a system which, while it forbade extravagance, checked development, committed fewer faults than any others; but they did commit some faults. Notwithstanding the geometrical severity of their temples, the rigid exclusion of historical subjects from their sculpture of the best period, and the tameness of their use of colour in ceramic art, they have been in some things guilty of bad taste. Nothing could be more barbarous than to represent not only a human figure, but that of a woman, sustaining a vast weight, and sustaining it with difficulty. If it be excusable to represent giants thus supporting great masses, can it be to put women in their place as the columns on which a building rests? So, too, in sculpture—in a higher sense, and therefore as deserving far stronger censure—is false taste shown in the exclusion of historical subjects, because they were not capable of ideal treatment. Who can forgive a nation which was content to commemorate the battle of Marathon in a perishable painting, when meaningless combats of Grecks and Amazons, sculptured in enduring marble, adorned the walls of its temples? Great Pericles must be represented in a helmet, because his head was too long to be symmetrical. Thus the Greeks, with their love of material beauty, could not fully perceive the intellectual beauty of truth. In ceramic art, we find even in the best period faulty forms and exaggerated designs. We must the more carefully look for such things since the general excellence and uniformity of Greek high art is apt to deaden the power of discrimination. So long, however, as we know that this was a human art, worked out by human hands, which, like all other art, had its infancy, its manhood, and its decline and death, we know that it cannot have been perfect, and mistrust our judgment if for a time we think it so. Feeling thus, we come to the consideration of any monuments of Greek art, not without earnest admiration and respect for its high beauties and excellencies, yet conscious of its defects and shortcomings; expecting to see in it, as in all human things, the mysteriously-blended good and evil, and carefully maintaining such an independence as may enable us to avoid blind admiration, and such an interest as may preserve us from cold criticism.

Excellence in art is not perceived at the first search, nor does it shine out in the boldest objects. So in nature the highest beauty often demands the greatest toil, and is found at last, not flaunting in the glare of sunlight, but hidden in some untrodden recess. We must not look to size, nor regard boldness, nor think of the value of the material. We must even set aside the mechanical fineness of execution, seeking only that pure excellence that requires no adventitious aid, and is seen, at least in its intention, through a rude exterior. A few lines by the hand of a master have more meaning than the most elaborate work of a copyist. It is also needful carefully to separate the subject from the artistic execution. A fine head will often give a medal a supposititious excellence, while another difficult to treat will produce an equally supposititious badness.

The art of Greek coins, strictly so called, is separated into three great periods—the period of advance, that of excellence, and that of decline. The first period extends from the time

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of the earliest coins to about the commencement of the administration of Pericles, B.C., 440; the second period extends for about a century from this era to the overthrow of Greek liberty, which we may date at the battle of Chæroneia, B.C. 338; and the third period extends downwards to the cessation of the Greek coinage, at the death of Gallienus, A.D. 268. The last age might be held to conclude with the commencement of the Roman empire, since about that time the decline of pure Greek art had been completed, and the later coins are rather to be considered as Græco-Roman in art, as in all else, than Greek. Here, however, we limit ourselves to the works of the second period, that of excellence, to which we have assigned a duration of about a hundred years, from B.C. cir. 440 to 340. These may be considered as extreme limits, since in some Greek cities the coinage did not attain its highest beauty until somewhat after the rise of Pericles to power, and in none, before his time; and in the same manner, the decline appears in some cities to have commenced considerably before the reign of Alexander, but nowhere at a later period. It seems probable, judging from the chronological and historical indications of coins, as well as from the relative number of those of different styles, making, in the latter case, some necessary allowances, that in no city or state did the period of excellence last more than a century, and that its usual duration was from fifty to seventy years.[1]

Best period.

The finest Greek coins may be separated into two great classes, distinguished by a marked difference of style: those struck in Greek cities of Asia, of eastern Europe, and of the islands of the Ægean Sea; and those struck in Italy and Sicily. The former class has far finer designs than the latter, but is frequently deficient in execution, partly, no doubt, on account of its having been issued by less opulent cities. The difference is not unlike that which we observe in ancient and modern gems, although it is not nearly so wide. An ancient gem of good time is characterized by an excellence of design, usually combined with an execution which is, however powerful, poor and rude. A modern gem rarely fails in skilful execution, although its design is generally, in comparison, either tasteless or in bad taste. The coins of Greece Proper and its eastern colonies during the best period, although often indifferently executed, show an unequalled vigour of drawing; while those of the Italian and Sicilian cities display far inferior art, of which the details are worked out in the most elaborate and delicate manner. The obverse-type of a coin of the Greek class looks like the copy of a head from the sculptures of the Parthenon; that of one of the Italian class, like a carefully-wrought gem. The former will bear magnifying rather than the latter, which has, nevertheless, the advantage in the execution of its details. We may thus separate two great schools, which may be compared to those of Phidias and Lysippus, as possessing like them these main characteristics: that the one aimed at reality,—the other at effect; the one at representing things as they are, either in reality or in the imagination,—the other at representing them so as to be seen to the best advantage. While the two schools endeavoured to attain the same result,—a representation of what was most beautiful,—they did so with a very different feeling. The nobler school set before it the perfection of various kinds of beauty, the vigorous as well as the delicate, and thus did not suffer itself to be entangled by that narrow pursuit of one class of objects which infallibly produces mannerism. The inferior school, by requiring all beauty to be soft, and delicate, and rich, fell into the error of neglecting many noble subjects, and soon acquired a mannerism that rapidly destroyed its best elements, so that its decline (as shown by coins of known date) was far more rapid than that of the other. The difference between the two schools is best perceived when we recollect that the one contains examples of all that is finest in the other, with the addition of many beauties which it does not possess. The Greek school represents, in fact, all high Greek art; while the Italian is but eclectic, and is almost limited to one kind of excellence. We therefore only call the former a school for the sake of clearness.

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Pure Greek school.

The coins of the pure Greek school have scarcely been enough studied for us to be able to point to one well-known series as typical of the class. This is, however, partly owing to a cause to which allusion has been already made—the fewness of fine coins of this school in comparison to those of the Italian school of the same time, resulting from the relative poverty of the towns by which they were issued. The rude archaic types of the Athenian coinage of the time of the Persian invasion were maintained until art had far declined, probably from commercial reasons;[2] and the art of the chief trading cities of the west coast of Asia Minor was checked by their conquest or government by the Persians at the time of its excellence. Corinth alone, of the great marts, sent forth a consistently beautiful coinage. The Italian and Sicilian towns, on the other hand, had wealth and leisure enough to carry out efficiently in their coinage their highest idea of beauty. The series which, as a whole, best illustrates the excellencies of the Greek school, is one not deservedly known to numismatists, while it is absolutely unknown to students of art. This is the series of electrum coins of Asia Minor, in so far as it was issued during the period of the best art. The rest of the finest coins of this school are almost exclusively silver; gold or electrum not having been generally common in the Greek cities before Philip's time, and the copper money having been usually neglected. As among the most beautiful Asiatic coins, we must particularize those of Clazomenæ in gold and silver, of the early part of the best period, which bear heads of Apollo, facing, in the boldest and grandest style. In Europe, many of the cities of Macedon, Thrace, and Greece Proper, issued pieces of the highest merit. Nothing in the whole range of Greek art is more beautiful than the head of Apollo in profile on coins of the Chalcidians; nor anything bolder than that of Bacchus in profile on a coin of Thasos, and that of Mercury, facing, on coins of Ænus. In Greece itself, we may notice, as among the finest coins, those of Elis, with the head of Juno, and those of the Locri Opuntii, with that of Proserpine. After a careful review of the best specimens of this school, we perceive that it is identical with the highest school of sculpture, more remarkable for its fidelity, breadth, and boldness, than for its minuteness of execution, and equally happy in purely ideal subjects and in the simple portrayal of natural objects. There are no finer representations of the Greek divinities than those borne by the coins; as a series there are none as fine. Of the portraits the same can be said, but in a lower sense, since there is but one that belongs to the period of the highest art, that of a Persian ruler of Asia Minor, whom there is much reason for supposing to be Cyrus the Younger, on a coin of a Greek mint. The decline of this school was, however, so gradual, that some of the portraits on coins of the earlier part of what we have called the third period, issued in Greece and the East, give an excellent idea of what the best Greek medallic art could have effected in this direction. The representation of natural objects in general is characterized by an equal degree of force and vigour, although there is no attempt to idealize the animals; a lion is a lion, and nothing more.[3]

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[1] It is interesting to compare the duration of the highest Greek art in other branches, and that of other art in different ages. The period of the best Greek sculpture and architecture appears very nearly to correspond to that of the best numismatic art in place and duration, though probably it was a little earlier both in its commencement and its conclusion. The age of the best painting seems to have been even more nearly contemporary with that of the finest coins. The great sculptors and painters after the time of Philip, if we may judge from the copies of their works and the descriptions that are extant, stood very much in the same relation to their predecessors that the later Italian painters did to Raphael. The best Græco-Roman art, in coins as well as in sculpture and architecture, had a longer duration, a circumstance which is explained by its comparative mediocrity; but its utmost limit is less than two hundred years. In more ancient times, the highest Egyptian art in architecture and sculpture is likewise limited to a hundred and fifty years, although its rise and decline were of an extremely gradual character. The great variety of the developments of Christian architecture make it difficult to determine its best periods; but if we separate it into styles, we shall find that the highest excellence of no one much exceeded a century and a half. The same is still more true of the modern schools of painting and sculpture, and of the art of modern coins and medals. If we turn to the East, we observe the same law in the different styles of Mohammedan architecture. The brief duration of the highest art of Greek coins is therefore in no way remarkable; especially when we recollect that its excellence was the result of a very rapid development, and was thus naturally, so to speak, as short-lived as it was extraordinary in its beauty.

[2] The maintaining of the old Athenian types was probably owing to the reputation of the coins for purity and just weight among the barbarians. For the same reason the Austrian government not long ago re-issued the dollars of Maria Theresa for the trade of the Levant. The Abyssinians in general would lately take no money but one variety of these dollars. (Isenberg's *Amharic Dictionary*, p. 86).

[3] It might seem unreasonable to suppose that the lower animals could be treated in art in an ideal manner; but it must be remembered that the

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Italian school.

The most beautiful coins of the Italian school, unlike those just noticed, are well known to every one. They have come to be regarded as examples of the highest Greek medallic art; and hence, perhaps, in some measure the unworthy estimate of that art shown by the neglect with which it is treated. The two most beautiful series are unquestionably those of Tarentum and Syracuse, the wealthiest of the Grecian colonies in the West. Many of the gold coins of both cities belong to the best period of art, and for their rich beauty and exquisite workmanship deserve a high place in the scale of artistic excellence. Their silver coins are still more worthy of careful study, as indicating the growth and decline of art, and as sometimes excelling the gold. The same praise cannot be given to the decadrachms of Syracuse, commonly called the Syracusan medallions. These, though certainly beautiful, display a considerable decline of taste, showing a first development of those faults which amount to caricature in many of the coins of the Carthaginians of which the obverse is similar. Scattered throughout the class there are coins of extreme beauty, especially some of the towns of Heraclea and Thurium in Lucania, perhaps the most vigorous of all in design and treatment; and others of Neapolis, Metapontum, Velia, and Terina, as well as of the Sicilian town of Camarina. These coins, and many others, are undoubtedly extremely beautiful; but as a class they lack the force which characterizes the purer school, and in their rich and profuse detail show a taste which must be pronounced false. We are apt to be dazzled in judging them by the fineness of their metal, the clearness of the execution, the accuracy of the work, and the richness of the designs; but when we come to examine them critically, we look in vain for the bolder excellence of the Greek school; we see not alone very few things that are vigorously treated, but scarcely any that would bear vigorous treatment. Stripped of their ornamentation, many of the designs would be weak, and scarcely any of them, tried by this test, would be for a moment comparable with those of the Greek school.

Modes of coining.

It is important to study the mode in which Greek money was coined, because the forms of the pieces thus receive explanation, and true coins are discriminated from such modern falsifications as have been struck, and in some degree from those which have been cast. Our direct information on the subject is extremely scanty; but we are enabled by careful inference to obtain a very near approximation to the truth on all the most important points.

It is generally supposed that a certain Roman family coin, issued in the time of Augustus, bears a representation of the instruments of coining. It is a denarius of the family Carisia, and sometimes bears the name of T. Carisius, who was a *triumvir monetalis* of Augustus. On the obverse is the head of Juno Moneta, with sometimes the name MONETA; on the reverse we see an anvil, above which is the cap of Vulcan, bound with a laurel-wreath, while on the right is a hammer, and on the left a pair of tongs. The cap is but little different in form from that which is worn on the head of the bearded Vulcan on the coins of Lipara, and that of the young Vulcan on those of Æsernia; the latter of which has a wreath like the cap of the denarius under discussion. It is also to be noted, that on some coins of Lipara, Vulcan is portrayed holding his hammer in his right hand, and in his left a vessel he has just formed; while on those of Æsernia already mentioned the pair of tongs is placed behind his head as an appropriate symbol. Homer in two passages—the second of which Eckhel quotes—mentions the anvil, tongs, and hammer, as the implements of Vulcan, or of a worker in metal. First in the *Iliad*, when he describes Vulcan making the armour of Achilles, he says—

Θῆκεν ἐν ἀκμοθέτῳ μέγαν ἄκμονα· γέντο δὲ χειρὶ
Ῥαιστῆρα κρατερὸν, ἑτέρῃφι δὲ γέντο πυράγρην.
(*Il.* xviii. 476-7.)

In the *Odyssey* the same are mentioned as the special implements of a worker in metal, and therefore, of course, of Vulcan:—

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ἦλθε δὲ χαλκεὺς,
Ὅπλ' ἐν χερσὶν ἔχων χαλκήϊα, πείρατα τέχνης,
Ἄκμονά τε, σφῦραν τ', εὐποίητόν τε πυράγρην,
Οἷσίν τε χρυσὸν εἰργάζετο." (*Odys.* iii. 432-435.)

There could be no better description than these two passages afford of the implements represented on the denarius in question: there we see the anvil with the projections by which it would be fitted in the anvil-block, the hammer, and the tongs; nothing is omitted by the poet but the cap, which indeed, stands for Vulcan. With this explanation Eckhel perfectly agrees; but of late it has been usual to consider the type as representing the implements of coining. The cap has been supposed to be a die placed above the anvil, and the hammer and tongs to be here coining instruments. The form of the cap, however, would have been most inconvenient for a die, and the hammer is far better suited for beating out metal than for striking a very heavy blow. Just as the head of Juno Moneta is represented on the obverse because she was held to protect the coinage, so the symbols of Vulcan, the tools of his craft, are placed on the reverse because he was the patron of the workers in metal. We will go further and say, that such an explanation is fully in accordance with the intention which guided the ancient medallists, whereas the other would require a departure from usage.

We are able to describe but a single ancient die of the authenticity of which we are persuaded. Mr Burgon, to whose kindness we are indebted for an account of it, saw it during his residence in the East, but failed to persuade its possessor to part with it. He describes it, from recollection, as a piece of copper or bell-metal, in the shape of a truncated cone, flat at the top and bottom, about 3⅛ inches in height, and from about 3 inches in diameter at the bottom to 2 at the top. In the upper surface was cut the die for the reverse of a tetradrachm of a Seleucide king of Syria, with the type of Apollo seated on a cortina. There appears to have been no trace of any method of adjusting this to the die of the obverse.

From the appearance which the coins present, it may be inferred that the Greeks placed a ball of metal, carefully adjusted to the proper weight, and cold, between two dies, and then struck the upper die a powerful blow with a very heavy hammer. There was no collar to give the coins an exactly circular form. The dies must have been of hard metal, though less so than modern ones. Some Greek coins have been found of the same die, but such as the writer has seen did not present any evidence as to the wear to which their dies had been subjected. The Roman coins appear to have been struck in the same manner, but with a more careful adjustment of the two sides, yet without a collar. Their dies, although hard, must have been, like the Greek dies, softer than those of the moderns, since, in the case of coins from the same die, we can trace the increase of imperfections through wear, and this notwithstanding the small period for which each die was used, and the relatively few coins struck from it. In the case of Greek coins, there is similar evidence, in the great number which have bad or imperfect impressions, although not worn; since all these can scarcely owe their inferiority to insufficient force having been used in striking them.

Some few Greek and Roman coins were cast and not struck; others, at least in the latter series, were first cast to give them their general form, and then struck. Both cases, however, form very rare exceptions, and are confined to particular groups of coins, and not to isolated examples.

Monetary system.

The monetary system of which we propose now to speak is that of the Greeks and Phœnicians alone. The barbarians who imitated Greek coinage, and whose money is therefore included in the same great class, had also monetary systems, as the general exactness of the weight of the gold and silver coins of any one people at a particular period undoubtedly shows. For the present, however, we must be content to collect evidence as to what these systems were, without attempting to form theories.

The money of the Greek cities, except those of the west of

Greeks idealized the human form, not alone in those expressions which depend upon mind, but in those which are not more than animal. The Egyptians, however, in one particular at least, surpassed them, since they idealized the forms of the lower animals with complete success. The lions in the British Museum, brought by the Duke of Northumberland from Gebel Berkel in Ethiopia, are the best examples of this success in the collections of Europe. They show that the artist has grasped the idea conveyed to him by a lion—conscious strength; and has represented it in a manner which is sublime without being unnatural. No Greek lions are at all to be compared to these.

Greek Coins.

Asia Minor, which issued electrum coins, appears to have been of silver only from the origin of coinage until after the expedition of Xerxes. Subsequently both gold and copper money was issued. Silver, however, seems to have continued to be the standard, and the gold coins were struck in denominations, usually, if not always, derived from the silver ones. Silver, therefore, is the most important metal.

Silver money.

The denominations of silver coins were divisions of the mna or mina, which again was a division of the talent. The mina and talent were monies of account as well as weights, and therefore, in discussing the coinage, they may be treated as coins. The only reason that they were not struck must have been their great weight. Although the same system of denominations obtained, with no very great variation, in all the Greek and Phœnician cities, yet there was a relative difference of weight, owing to the use of at least four distinct talents. The ancients mention more talents than these, or else call some of them by more than one name. Mr Burgon, however, after weighing a great number of coins, found no reason to distinguish more than four talents—the Attic, the Æginetan, the Alexandrian or Ptolemaic, and the Tyrian. The Attic talent was used by many Greek cities before Alexander's time, and particularly had no rival in Italy, nor indeed in Sicily, except at two towns for a time at a very early period. Alexander adopted it, and thenceforward it became almost universal in Greek coinage. The weight of its drachm, as deduced from the best evidence, was properly about 67·5 grains troy, and that of its tetradrachm about 270. There was in general no very great depreciation of the Attic weight in subsequent times until the Roman period. The weight of the principal denominations, the drachm and the tetradrachm, we have given to show the relation of the talents. Of the other denominations we shall speak afterwards. The Æginetan talent was as ancient as the Attic, and it is possible that it was even of an earlier origin, most coins of the remotest period being adjusted to it. The Attic talent was, however, the standard of some of the oldest coins, and the instances of the change from the Æginetan to it are not, on the whole, of a character that would warrant the conclusion that it was of later origin. The Æginetan talent is frequent in Greece and the islands in early times. Its drachm weighed about 96 grains, and the didrachm about 192 grains. The Alexandrian or Ptolemaic talent might, Mr Burgon holds, be more properly termed the Macedonian. The first Ptolemy, who was attached to all Macedonian usages, abandoned the Attic weight which Alexander had adopted, and issued money adjusted to the old talent of Macedon. We find this talent to have been that of the earlier coinage of the cities of Macedon and Thrace, and of the Macedonian kings, in both cases before Alexander the Great, and to have been restored, not invented, in the coinage of the kings of Egypt. In the former class, its drachm weighs originally about 58 grains, and its tetradrachm about 232 grains, but they fall gradually to much lower weights. In the latter class, the drachm weighs originally about 55 grains, and the tetradrachm about 220 grains. The Tyrian, which might rather be called the Phœnician talent, was in use among the Persians and Phœnicians. The Carthaginians, however, adopted the Attic talent in Sicily, while still using the Phœnician in Africa, as the kings of Syria struck their general coinage on the former system, but that of their Phœnician cities on the Alexandrian. The drachm of this talent weighed, according to Mr Burgon, between 58 and 59 grains, and the tetradrachm about 235.[1] The earlier Persian coins are of a somewhat heavier weight. The similarity of weight of the Alexandrian and Phœnician talents might suggest a common origin, but it would be hazardous, with the slight evidence we possess, to attempt to form any theory on the subject.

We are best acquainted with the denominations of the coinage of Athens, which followed the Attic talent. These denominations were—the drachm, with its multiples, and its sixth part, the obolus; and that division, with its multiples and its divisions. The following list is drawn out from that in Col. Leake's *Numismata Hellenica* (European Greece, p. 21), where the standard weight of the Attic drachm is assumed to be 67·5 grains :—

1. Δραχμή	67·5 grains troy	=	1 drachm.
2. Δίδραχμον	135·0 „	=	2 do.
3. Τετράδραχμον	270·0 „	=	4 do.
4. Δεκάδραχμον	675·0 „	=	10 do.
5. Ὀβολός	11·25 „	=	⅛ of drachm.
6. Τριημιοβόλιον	16·87 grs. troy	=	1½ obolus.
7. Διώβολον	22·5 „	=	2 oboli.
8. Τριώβολον, or Ἡμίδραχμον	33·75 „	=	3 oboli, or hemidrachm.
9. Τετρώβολον	45·0 „	=	4 oboli.
10. Πεντώβολον	56·25 „	=	5 do.
11. Τριταρτημόριον, or Τριτημόριον	8·43 „	=	⅜ of obolus.
12. Ἡμιοβόλιον	5·62 „	=	½ do.
13. Τεταρτημόριον, or Ταρτημόριον	2·81 „	=	¼ do.

Greek Coins.

There were 100 drachms in the mna or mina, and 60 minæ in the talent.

In the civic money for which the Attic talent was used the most common piece was either the tetradrachm or the didrachm. Thus, at Athens the great currency was of tetradrachms, at Corinth of didrachms. In the money of the kings the tetradrachm was the chief coin. The smaller pieces were numerous, though fewer than these two most important denominations, except in the lesser cities, which did not frequently strike the latter. A smaller coin that is very frequent in the later period appears to have been an Attic tetrobolon, but was probably also considered to be an Æginetan hemidrachm, since it was introduced not long after the general abandonment of the system of the latter, and when its weight would have been preferred, from its near approach to that of a well-known coin of that system. Those cities which used the Æginetan talent are not known to have issued any larger piece than the didrachm, which is their principal coin. The drachm and hemidrachm are, however, also frequent. In the Alexandrian talent the most common pieces, during the early period, when it should rather be called Macedonian, were the tetradrachm, didrachm, and drachm. At first octodrachms were struck. Under the Ptolemies the common coins were tetradrachms, but decadrachms were also issued. The system of the denominations of the Tyrian or Phœnician talent was somewhat different from that of the other talents, though not essentially so. The principle of division into thirds, seen in the Attic talent in the case of the obolus, which is the sixth part of the drachm, is more fully developed in the Phœnician talent. The Carthaginian coins are principally tetradrachms and didrachms, but dodecadrachms and decadrachms also occur, as well as drachms and smaller pieces. In the cities of Phœnicia tetradrachms were the largest and the most important coins. In the Persian series the principal pieces are tetradrachms and coins of a third of their value, with different types, which are usually called silver Darics. It is probable that this system tended to produce the issue of the pieces called cistophori by the cities of the west of Asia Minor at a late period. These coins must originally have been struck as Attic tridrachms; but they appear afterwards to have been considered to be tetradrachms, and if this be established, they are examples of a fifth system. It is probable that the names of most denominations were the same among the Greeks, and that the Persians and Phœnicians had a different nomenclature, although the Greeks would have called their coins, in so far as they agreed with their own, by Greek appellations.

Gold money.

The gold and electrum coinage appears to have been everywhere based upon the silver in its denominations; for, although in many cases it is very difficult to arrive at even a probable conclusion, from the fewness of specimens, all the direct evidence seems to be in favour of this opinion. The oldest coins are the electrum staters of the west of Asia Minor, commonly called in ancient times Cyzicene staters. Their weight is about 248 grains, which is a little in excess of that of the Phœnician tetradrachm. It contains, however, only about 186 grains of pure gold, three-fourths of the whole weight, the remaining fourth being of silver, and as the latter appears not to have been taken into account, the relation seems rather to have been to the Æginetan didrachm. There were smaller denominations, of which one, the hecta, which was the sixth part of the Cyzicene stater, was very common. Other pieces appear to have the weight of the third of the stater. The Persian staters, anciently called Daric staters, and now gold Darics, are of pure gold, and are in weight equivalent to rather light didrachms of the Attic talent. In European Greece there is little gold money before the time of Philip of Macedon. He issued staters of the weight of Attic didrachms. Subsequent kings struck distaters, or gold tetradrachms; hemistaters,

[1] *Thomas Catalogue*, Greek, &c., Coins, p. 57.

Greek Coins.

or gold drachms; and smaller coins. The largest known coin of the cities which was struck in gold is the stater, and it is usually less common than lower denominations. The system upon which this coin, which may be considered to be the basis of the gold money, was subdivided, has not yet been fully determined. The Ptolemies struck staters, adjusted to the Alexandrian talent, as well as octodrachms and pentadrachms.

Copper money.

There are at least two distinct systems of denominations of Greek copper money anterior to the Roman domination, which we may term the Greek and the Italian. Of the former system the principal coin was the chalcus, or piece of brass, of which eight went to the obolus of silver. There was a smaller piece called a leptum, of which the chalcus is said to have contained seven. The coins have usually been so carelessly struck that it is difficult to separate them by weight. The Italian system, which was used in Italy and Sicily, and does not seem to be of foreign origin, is better known. The weight is more accurate, and the value is frequently marked upon the coins. The highest denomination was the as, according to the Roman nomenclature, which was at first, nominally, the pound coined, and was thence called *as libralis*; and the unit was the uncia, or ounce, its twelfth part. The common divisions were the semissis or semis, the half of the as; the triens, or third; the quadrans, or quarter; the sextans, or sixth; and the uncia. Although originally these were coined at near their full weight, they were afterwards rapidly reduced, until at length the as contained but half an ounce of metal.

(The most important works on the entire class of Greek coins may be here mentioned. The account of Greek coins in Eckhel's *Doctrina Numorum Veterum*,[1] will be found to contain the condensed result of the studies of the author's predecessors, with much valuable matter of his own. Although not equal to the part relating to Roman coins, this treatise is of very high merit, and has not yet been superseded. Sestini, in his *Classes Generales*,[2] has published an excellent companion and supplement to Eckhel. Following that author's arrangement, he has enumerated the principal inscriptions of Greek coins, and has thus afforded great assistance to those who are engaged in their classification. Mionnet's voluminous *Description de Médailles Antiques*, &c.,[3] is very useful, but of little authority. It is a catalogue of Greek coins, compiled with much industry by one who had great practical knowledge, but who was not otherwise qualified to attain a high place as a numismatist. Colonel Leake has lately published a catalogue of examples and electrotypes in his possession of coins of the Greek series, excluding most of those struck by barbarians.[4] The notices given in this work of the geographical, historical, and mythological references of the coins are of high value. The most important work on the weights of Greek coins is Böckh's *Metrologische Untersuchungen*.[5])

Greek coinage of different countries.

We may now pass on to notice the Greek coinage of each country, following Eckhel's arrangement.

The series commences with Spain, Gaul, and Britain, three countries of which the money presents a general resemblance, constituting the only great class of barbarous Greek coinage. It must not be supposed that the money of the whole class is of one general character; on the contrary, it has very many divisions, distinguished by marked peculiarities: it has, however, everywhere one characteristic in common,—that its devices are corrupt copies of those of Greek or Roman coins. The earliest of these barbarous coins appear to be the best imitations of the gold and silver money of Philip II., King of Macedon. Next in order of time come the imitations of Roman family coins, the denarii of the commonwealth, in both Spain and Gaul, and that copper money of the former country which followed its silver imitated types. There are in these coinages evident imitations of Greek designs, besides the Macedonian ones we have mentioned, to which it is not easy to assign a chronological place, though they are probably anterior to the imitations of the Roman coins, but not to the more accurate money of Greek colonies, especially Massilia in Gaul. It is useless to attempt a very minute classification of the subjects of these barbarous types, since the artists by whom they were executed did not properly understand them; and we must be contented if we can perceive the general though accidental principles to which they owe their origin.

Greek Coins.

Spain.

The coinage of Hispania or Spain, corresponding to the modern Spain and Portugal, was issued during a period of not more than three hundred years, from about B.C. 250 to A.D. 41. The earliest coins can scarcely be carried further back than B.C. 250, and probably were issued long subsequently; while the latest are of the reign of Caligula, during, or at the close of which, the coinage was evidently stopped. The money of this period was of four classes,—the Celtiberian, or native; that of the Phœnician, and that of the Greek colonies; and the Roman coinage. To the Celtiberian class specimens of the earliest period of Spanish coinage undoubtedly belong; so that its commencement was about, or probably after, B.C. 250. Its cessation must have been caused by the subjugation of Spain to the Roman commonwealth in the middle of the second century B.C. The coins are of silver and copper, no gold pieces being known. In form they are flat, and, in the case of the copper, rather thick. The silver have the general appearance of Roman family denarii, of which, indeed, they are imitations; while the copper again are imitations of the silver. The most common obverse-type of the coins in both metals is the head of a divinity, and the reverse-type a horseman or two horsemen. The inscriptions are in Celtiberian characters, and appear to be always the names of the cities, and perhaps also tribes, by which the coins were issued. The Celtiberian alphabet is manifestly of Phœnician origin; but the language which it was employed to express appears to have been that of the aboriginal inhabitants, represented by the modern Basques. The art of these coins is barbarous. With reference to their denominations, it must be remarked that the most common silver pieces have about the same weight as the Roman denarii of the period, and the Greek-Attic drachms, then nearly equal to the denarii. It is not easy to decide from which of the two it was adopted, but the balance of evidence seems to predominate in favour of a Roman source.

The change from the Celtiberian to the Latin coinage does not seem to have been abrupt. We find certain coins with inscriptions indicating a transition, while in art and types they show a relation to the later Celtiberian pieces, as well as to the earliest Roman. Their inscriptions are either bilingual, in Celtiberian and Latin, or else they are written partly with Celtiberian and partly with Latin characters.

Phœnician and Greek colonies issued money of their own during the period of the Celtiberian coinage. The Phœnician coins, such as those of Gades, have types which are not without meaning, but their execution is very barbarous. The Greek coins, as those of Emporiæ, have types which show a distinct meaning, although they are executed with a coarseness often amounting to barbarism.

The Roman coins of Spain, besides those which bear inscriptions in Latin and Celtiberian, of which we have already spoken, are of two periods,—that of the commonwealth, and that of the empire. The money of the former class differs little in art or intention from the Celtiberian coinage, which it superseded; but that of the latter shows a considerable change in the character of the types. The imperial coins were all issued by Roman coloniæ. Their art cannot be said to indicate any important progress, but their inscriptions are accurate, and the types display a distinct intention. Their obverses bear the head of the emperor, or of some imperial personage, while the reverses have types usually referring to the foundation of the coloniæ by which they were issued. Among the most common reverse-types may be specified the emperor or a priest guiding a plough drawn by two oxen, a subject representing the ceremony of describing the extent of the walls; an ox, intended to convey the same idea; an altar, sometimes called in the inscription the altar of Augustus, the founder; and a temple.

The following are the most important coins in the three provinces of Hispania:—In Lusitania we may notice the imperial money of its capital, Augusta Emerita, which took its name from its having been a settlement of pensioners (*emeriti*). The denarii of the legate of Augustus P. Carisius, which bear the name of this place, were perhaps struck at Rome. In Bætica, the series of the Phœnician colony Gades is especially worthy of note; and in Tarraconensis, those of the Greek colonies Emporiæ and Rhoda. The money of the Spanish island of Ebusus is of a remarkably Phœnician character.

(The principal books upon Celtiberian coins are M. de Saulcy's *Essai*,[6] and two works by M. Boudard,[7] the second of which, now in

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[1] *Doctrina Numorum Veterum* conscripta a Josepho Eckhel, 8 vols. 4to, Vind., 1792–1798.

[2] *Classes Generales seu Moneta Vetus Urbium Populorum et Regum ordine geographico et chronologico descripta*, editio secunda, 4to, Flor. 1821.

[3] *Description de Médailles Antiques Grecques et Romaines avec leur degré de rareté et leur estimation*, par T. E. Mionnet, 6 vols. and 1 vol. plates, 8vo, Paris, 1806–1813; *Supplément*, 9 vols. 8vo, 1819–1837. The terms *Grecques* and *Romaines* are here used for "Greek autonomous" and "Greek imperial." The indexes in the ninth volume of the Supplement are especially useful.

[4] *Numismata Hellenica, a Catalogue of Greek Coins collected by W. M. Leake*, 4to, London, 1854.

[5] *Metrologische Untersuchungen über Gewichte, Münzfüsse, und Masse des Alterthums*, &c., von August Böckh, 8vo, Berl. 1838. It is unfortunate that this learned author was not so fully acquainted with the numismatic as with the literary materials for his subject. From the researches of Don V. Veazquez de Queipo much information may be expected. The writer is indebted to him for much liberal assistance.

[6] *Essai de Classification des Monnaies Autonomes de l'Espagne*, par F. de Saulcy, 8vo, Metz, 1840.

[7] *Etudes sur l'Alphabet Ibérien et sur quelques Monnaies Autonomes d'Espagne*, par P. A. Boudard, 8vo, Paris, 1852;—*Numismatique Ibérienne*, par P. A. Boudard, 4to, Paris (in progress).

Greek Coins. Gaul.

progress of publication, promises to be a very complete treatise. There is also an excellent sale-catalogue, by M. Gaillard, of a large collection of Spanish coins, and coins current in Spain in ancient and modern times, formed by Don Garcia de la Torre.[1])

The coinage commonly called that of Gaul should rather be classed to the Gauls, since it belongs to the people more properly than to the country; for, in addition to the money struck in the territory called after them, it comprehends pieces issued by the Gauls or other barbarians near Macedonia and Illyricum, and in the south of Germany. The Gaulish coinage appears to have generally extended over a period of less than four centuries; for the oldest pieces, as far as we can ascertain, are those which follow the types of Philip II. of Macedon, and the latest are the Roman of Augustus.[2] Some of the Greek coins of Massilia may be of a time somewhat anterior to that of Philip. There are two principal classes,—the true Gaulish coinage, and that of Gaul under the Romans.

The ancient Gaulish coins are of gold (often greatly alloyed with silver or copper), of silver, of copper, and of potin. They are usually convex, and, in the case of the gold and potin, generally thick and heavy. The earlier designs are copied from those of Greek money, the gold and silver coins being imitations of the staters and tetradrachms of Philip II. of Macedon. At a later time the silver and copper coins of the Gaulish chiefs and tribes chiefly follow the designs of Roman denarii of the commonwealth and the beginning of the empire. The early class is uninscribed, except when part or whole of the Greek legend is imitated; but the later class bears Latin inscriptions. The art of both is barbarous, although that of the later class is better than that of the earlier in this respect. There appear to be two monetary systems, but they are not clearly made out; although it is most reasonable to consider them to have been imitations, the one of the Macedonian system, and the other of the Roman.

The money of the important Greek colony of Massilia forms a separate class with that of the far less noted towns of Antipolis and Beterra, in the same division of Gaul. It was issued during at least three full centuries preceding the subjugation of the country by the Romans. Its metals are silver and copper, gold coins not having been discovered. The designs and inscriptions are purely Greek, and the art, in the case of Massilia, is not unworthy of an isolated colony. The denominations appear to follow the Attic talent.

The proper Roman coinage of Gaul is, as far as is known, of copper only, although there is silver as well as copper money of some reguli protected by the Romans before the complete reduction of the country. This Roman money is of a few coloniæ alone. Like the contemporary Spanish pieces of the same class, the coins are large and coarsely executed. On the obverses there are commonly two heads,—either those of Augustus and Julius, or Augustus and Agrippa, back to back. The designs of the reverses appear usually to relate directly or indirectly to the establishment of the coloniæ. The inscriptions are in Latin, and the denominations seem to follow the Roman system.

Some of the more important or interesting coins may be now indicated in the order of their proper arrangement. Here we deviate from the principles of those continental numismatists who comprehend all the coins of Britain under Gaul. While admitting the common general character of the money of the two countries, and that some coins virtually identical may have been struck on both sides of the Channel, we perceive a sufficient difference in the majority of specimens found in England and on the Continent to render a distinction necessary. Besides this, many of the coins found in our own country bear names which are undoubtedly those of British towns or chiefs, such as Verulamium and Cunobelinus. It is not easy to define in a few words the main particulars in which early Gaulish and British coins differ; but it may be said that the former are generally in a style either somewhat better or much worse, especially in the quality of grotesqueness, than that of the latter. Passing by Gallia Aquitanica, as numismatically uninteresting, we may notice in Gallia Narbonensis the coins of the Greek city of Massilia, some of which, in the silver series, are of great beauty, although the larger proportion are below the average of Greek money of the period in their art. The Roman coloniæ Nemausus and Vienna, in the same division of Gaul, are represented by copper coins of some interest. Those of the former place have for their type of reverse a crocodile chained to a palm tree, in commemoration of the subjugation of Egypt by Julius or Augustus, and those of the latter bear the device of a galley passing a castle. Among the towns of Gallia Lugdunensis, Lugdunum (called on the coins of the empire *Copia*) may be pointed out for its autonomous and imperial money. Besides these coins of cities, there are many having the names of Gaulish chiefs and tribes. Some of these are classed with the cities, because the position of the territories they ruled or occupied in one of the great divisions of Gaul is known; but others cannot be so placed, and are therefore arranged alphabetically, after the geographical series. Among the last are many uncertain names, which may be of towns, tribes, or chiefs. Especial caution is needed in any attempts to find the historical places of Gaulish chiefs. The information to be derived from their coins is so meagre that there is great danger of mistake in such endeavours. If, for example, the name of a chief is read, and the position of his territories ascertained, it does not follow that he is identical with one bearing the same name, and holding the same territories, mentioned by an ancient author; yet the contrary supposition is not unnatural. At the end of the Gaulish series are placed the uninscribed coins, some of which are among the earliest pieces issued by the Gauls, while others are probably of various times in the subsequent periods of their native coinage until its very conclusion.

Greek Coins.

(The principal works upon the coins of Gaul and the Gauls are,—the learned treatise of M. Lelewel;[3] the accurate *catalogue raisonné* of Gaulish coins in the French Collection, by M. Duchalais;[4] the account of the money of Gallia Narbonensis, by M. de la Saussaye;[5] the essay on that of the north-west of France, by M. Lambert;[6] and the papers of the Marquis de Lagoy on various Gaulish coins.[7])

Britain

The ancient coinage of Britain is of the period before the complete subjugation of the country by the Romans. It is manifest that it was derived from that of Gaul, but it is not possible to say how long after the origin of the latter. There are no coins of which we know the date until the time of the struggle with the Romans. Taking into consideration the general persistence of the types, and the regularity of the weight and fabric, of the whole gold coinage, it is most reasonable to suppose that it was issued during a period of about two centuries, closing cir. A.D. 43. It would therefore appear that the Britons had a metal currency at the time of Cæsar's invasion. The received text of Cæsar's *Commentaries*, indeed, states the very contrary; but Mr Hawkins has shown that the manuscripts, however they differ in the passage in question,[8] agree in relating that the use of either gold or copper money obtained among the Britons, and has traced the existing corruption to the editors of the middle of the seventeenth century. He cites a manuscript of about the tenth century, in the British Museum, which reads as follows:—"Utuntur aut ære aut nummo aureo aut annulis ferreis ad certum pondus examinatis pro nummo;" a statement, as far as the money is concerned, entirely consistent with numismatic evidence.[9] The silver coinage, it must be observed, is not known to have been issued until after Cæsar's time, no specimens which can be considered to be much anterior to Cunobelinus, who is believed to have been contemporary with Augustus, Tiberius, and Caligula, having been found. British coins are properly of but one class, since there is no money but that of the natives. The metals used are gold, silver, copper, and potin. The coins greatly resemble those of Gaul in form and general appearance, as already noticed. They are thick and convex, the gold being the most remarkable for their thickness. The types of the gold coins are taken from those of the Gaulish in the same metal; the obverses bearing some device based on a degraded form of the head of Hercules on the money of Philip II., which has become a pattern, or even an ear of corn; while the reverses have a horse, with a wheel or other symbols, standing in like manner for the chariot on the Macedonian pieces. The inscriptions are always in Latin. The art of the coins is barbarous, though it often displays a kind of conventional neatness of execution. The monetary system appears to be the same as that of the earlier native Gaulish money.

In arranging the British series, we place first coins bearing the names of known princes or towns; then those bearing unknown

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[1] *Description des Monnaies Espagnoles et des Monnaies Etrangères qui ont eu cours en Espagne*, &c., par Joseph Gaillard, 4to, Madrid, 1852.

[2] Strabo (lib. iv., cap. iii.), as Eckhel notices (*Doct. Num.*, vol. i., p. 65), speaking of his own time,—that is, of about the close of the reign of Augustus and the beginning of that of Tiberius,—mentions the striking of gold and silver money by the Roman prefects of Lugdunum. No coins, however, have been found which have the head of any one later than Augustus; and the known Roman imperial money of Gaul is of copper alone.

[3] *Etudes Numismatiques et Archéologiques*, par Joachim Lelewel, 1er vol., *Type Gaulois ou Celtique*, 8vo, Bruxelles, 1841 (with a volume of plates).

[4] *Description des Médailles Gauloises faisant partie des Collections de la Bibliothèque Royale*, par Adolphe Duchalais, 8vo, Paris, 1846.

[5] *Numismatique de la Gaule Narbonnaise*, par L. de la Saussaye, 4to, Paris, 1844.

[6] *Essai sur la Numismatique Gauloise du Nord-Ouest de la France*, par Ed. Lambert, 4to, Paris, 1844.

[7] *Description de Quelques Médailles inédites de Massilia*, &c., par M. le Marquis de Lagoy, 4to, Aix, 1834; *Notice sur l'Attribution de Quelques Médailles des Gaules*, &c., 1837; *Mélanges de Numismatique*, &c., 1845; *Essai de Monographie d'une Série de Médailles Gauloises d'argent*, &c., 1847.

[8] *Bell. Gall.*, lib. v., cap. 12.

[9] *Silver Coins of England*, pp. 8, 9.

Greek Coins.

names; and last, those which are uninscribed. Coins in the second division may be constantly transferred to the first by the careful observation of the places of their finding. The coins of the third division are probably the oldest. They occupy in type a middle place between the coins of Gaul of the same kind and the earliest inscribed British coins of which the date is known, and which are of about the time of Julius Cæsar or Augustus. There are no inscribed coins which can be referred with certainty to any chief mentioned by Cæsar. The earliest of known date are of Tasciovanus or Tasciovans, the father of Cunobelinus. He must have reigned about the time of Augustus, for we cannot place him earlier, since one of his silver coins shows a manifest imitation of a type of denarii of that emperor in its obverse and reverse; nor can we suppose his reign to have extended much later, since he was the grandfather of the famous Caractacus. The coins of Cunobelinus, the son of Tasciovanus, and Shakspeare's Cymbeline, are the most interesting in the British series. He is supposed to have been a contemporary of Augustus, Tiberius, and Caligula, an opinion which cannot be far wrong, since he was the father of Caractacus, and to have ruled over a territory extending from the Severn to the east coast, and comprising the country of the Cateuchlani, Trinobantes, and Dobuni.[1] His coins are of gold, silver, and copper; the gold pieces following the old barbarous types, with some improvement in execution; and the silver and copper having types derived from those of Roman coins, or at least showing Roman influence. They have the names of the king and his father, both generally abbreviated, and sometimes those of two towns where they were struck,—Camulodunum, his capital, probably represented by Maldon in Essex, and Verulamium or Verulam. There are coins bearing the inscriptions SEGO and TASC, which have been ascribed to the Segonax mentioned by Cæsar;[2] but Mr Evans assigns them, with more reason, to the tribe of the Segontiaci. This tribe he supposes to have been ruled by a chief called Epaticcus, known only by his coins, whom he conjectures to have been a son of Tasciovanus, and on his death to have shared his kingdom with Cunobelinus. Other coins have been ascribed to Boadicea, because they bear the inscription BODVO; but this must be considered to be a purely conjectural attribution.

(There is no general account of British coins which can be called complete. This is partly owing to the circumstance that their proper explanation has been the result of recent inquiries; but it is to be hoped that this deficiency will soon be supplied. The works of Ruding[3] and Hawkins[4] give a concise notice of these coins; there is an essay on those of Cunobelinus by the Marquis De Lagoy;[5] and the *Numismatic Chronicle* contains several most important papers on British money by Mr Evans.[6])

Italy.

The ancient coins of Italy occupy the next place in Eckhel's arrangement. They appear to have been struck during a period of more than 500 years, the oldest being probably of the beginning of the sixth century B.C., and the latest somewhat anterior to the time of Julius Cæsar. The larger number, however, are of the age before the great extension of Roman power, which soon led to the use of Roman money almost throughout Italy. There are two great classes, which may be called the proper Italian and the Græco-Italian; but many coins cannot be referred to either, since they present peculiarities of both. The proper Italian coins are of gold, silver, and copper. Of these, the gold coins are extremely rare, and can never have been struck in any large numbers. The silver are comparatively common, but the copper are very numerous and characteristic. Some of the silver coins have an incuse device on the reverse, which almost always is a repetition of that on the obverse: these are of Greek cities, but their fabric is nearly peculiar to Italy. There are also a few with a design on the obverse and a perfectly plain reverse. The most remarkable copper coins of this class are of the kind now called *æs grave*, some of which must be considered to be the early proper coinage of Rome, although others are known to have been struck by other Italian cities. These are very thick coins, some of which are of great size, while more have a rude appearance. The designs of the Italian coins are generally, if not always, of Greek origin, although the influence of the native mythology may be sometimes traced. The inscriptions are in Latin or Oscan, and follow a native orthography: sometimes on the earlier coins they are retrograde. The art of this class is generally poor, or even barbarous. The denominations appear to be Greek, except in the case of the copper money, which follows a native system. Of this system, which we have already noticed, the early proper Roman coins afford the best known examples. The Græco-Italian coins are of gold, silver, and copper. The silver and copper are very common, and the gold comparatively so, although struck by few states or cities. In form the silver and copper coins are thicker than those of Greece of the same period, but there is not the same difference in the gold. The designs are of Greek origin, although here, as in the proper Italian coins, but less markedly, can native influence be detected. This influence is evident in the frequent occurrence of types symbolically representing rivers, showing a bias towards the old nature-worship; and still more in the use of Latin inscriptions, with half-Etruscan forms of the letters on coins otherwise purely Greek. Of the best art of ancient Italian money we have already spoken, and we shall have occasion to mention some of its most beautiful examples. The denominations of the gold coins are unquestionably derived from those of Greece, according to the weight of the Attic talent, the heaviest being a stater of that talent. The lower denominations require to be carefully studied before they can be satisfactorily explained. The silver denominations are perfectly Greek, and follow the Attic talent: there are few tetradrachms, the didrachms are extremely common, and smaller denominations are usually not rare. We thus learn that the silver currency was chiefly of didrachms, smaller pieces being less used, and larger ones scarcely used at all.[7]

Commencing in the north of Italy, the first coins that strike us are those of Populonia in Etruria. The silver money of this place is especially remarkable for being generally of a peculiar fabric, already noticed, in which the reverse is left perfectly plain. In Umbria we may notice the æs grave of Tuder, and in Picenum that of Asculum and Hadria together,[8] and that of Hadria alone. In Latium would be placed the early coinage of Rome, were it not included in the separate class of Roman money, with the exception of the pieces issued by the Campanian towns with the name of the city. In the province of Samnium we observe a very remarkable series of coins issued during the Social or Marsic War by the Italian states confederate against Rome. They rose to obtain the rights of Roman citizenship, but their league was gradually broken by the conclusion of separate treaties by the senate with individual states. The earliest common reverse-type of their coins represents eight persons, who are probably delegates of the eight states which composed the original league, and certainly stand for those states, taking an oath over a sacrificial pig. The series, as it continues, commemorates the gradual violation of this engagement. The eight persons are reduced to six, the six to four, and the four to two. That these changes should be represented is the more remarkable, if we recollect that the war lasted but three years, from B.C. 90 to 88 inclusive. Some of the coins have Oscan, and others Latin, inscriptions.

In the money of Campania we observe fine Greek work, combined, in some cases, with inscriptions showing an Italian orthography and form of letters. The coins of Cales afford examples of good art in both silver and copper; their inscription is CALENO, apparently a genitive plural form. Those of Cumæ are generally of coarse design and execution; among them are some of an early time. The money of Hyria comprises didrachms of good work of the best period of art, and bearing very archaic retrograde inscriptions, as ANIϘY. Neapolis, the modern Naples, is represented by an extensive series, including fine silver coins, particularly di-

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[1] Ruding's *Annals of the Coinage of Great Britain*, 3d ed., vol. i., p. 98.
[2] *Bell. Gall.*, lib. v., cap. 22.
[3] *Annals of the Coinage*, &c., p. 97, *et seq.*
[4] *Silver Coins of England*, p. 8, *et seq.*
[5] *Essai sur les Médailles Antiques de Cunobelinus, Roi de la Grande-Bretagne*, &c., par M. le Marquis de Lagoy, 4to, Aix, 1826.
[6] "On the Date of British Coins," *Numismatic Chronicle*, vol. xii., p. 127; "On the British Coins attributed to Dubnovellaunus," vol. xiv., p. 79; "Remarks on 'The Coins of Cunobeline and of the Ancient Britons,' by the Rev. Beale Poste," vol. xiv., p. 126; "On some Rare and Unpublished British Coins," vol. xvi., p. 80; "On a New Type in Silver of Dubnovellaunus," vol. xvi., p. 176; "On a Method of Casting Coins in use among the Ancient Britons," vol. xvii., p. 18; "On the Coins of Cunobeline with the legend Tasciovani F.," vol. xviii., p. 36; "On some Rare and Unpublished Ancient British Coins," vol. xviii., p. 44; "On the Attribution of certain Ancient British Coins to Addedomarus," vol. xviii., p. 155; "Errors respecting the Coinage of the Ancient Celtic Kings of Britain," vol. xviii., p. 161; "On some Unpublished Types of Ancient British Coins," vol. xix., p. 64; "On a Gold Coin of Epaticcus" (in the press).
[7] We may hence infer the wealth of the population of Italy before the Roman domination, and the consequent high price of the necessaries of life. In Greece, on the other hand, except at the great towns, such as Corinth and Athens, we notice that the current money is in most places mainly of small denominations. The regal coinages are of course exceptions to this rule. The inhabitants of Greece were, however, less attentive to their copper coinage than those of Italy and Sicily, which may partly explain their having struck very small silver coins. The Athenians had no copper coinage, or one of a merely arbitrary value, when they issued a large number of the low denominations of silver money; but after they had struck copper coins of a real value, their smallest silver pieces were coined in a much less quantity.
[8] When the names or symbols of two or more towns appear on a coin, it is understood to commemorate an alliance, called on the Greek imperial money, Ὁμόνοια.

Greek Coins, Italy.

drachms, and copper coins as excellent in design, and usually coated with the beautiful blue or green *patina* produced by the soil of the neighbourhood. The coinage of the great Greek cities of Italy may be considered to begin with Neapolis, though that of the Italian cities does not here cease. In Numismatics it is impossible to separate money according to a strictly geographical or historical order.—The earliest coins sanctioned by the Roman state are classed as uncertain coins of Campania. Of these we shall speak in treating of Roman money, since to it they historically belong, although most of them are purely Greek in their art, and they are all rightly considered to be of the Greek class. In Calabria, Tarentum affords the largest series of any city of Italy, and one which is, for extent and beauty combined, second alone to that of Syracuse in all the West. The gold coins are extremely fine, and those of silver, which are principally didrachms, are interesting on account of the early style of some, and the exquisite work of others, the latter being of the best period. The usual types of the didrachms are, on the obverse Taras, son of Neptune and founder of the city, carried by a dolphin, and on the reverse a horseman, who, as we shall show in speaking of the coins of Sicily, appears to represent a victor in the horse-race at the Olympic games. The copper coins are few, and not remarkable. The money of the cities of Lucania is very interesting. Among the coins of Heraclea are didrachms of exquisite work, having on the obverse a head of Pallas, with the monster Scylla on the helmet, and on the reverse Hercules strangling the Nemean lion, a design of great vigour, and showing perfect anatomical knowledge. The series of Metapontum, or, to follow the Greek orthography, Metapontium, stands next in its silver to that of Tarentum in extent, and is as beautiful in its finest coins, the subjects of which are even better adapted for that delicate treatment in which the Italian and Sicilian artists especially excelled. The great majority of these coins are didrachms, although the tetradrachm has been discovered. They commence at an early time with didrachms of a class that we have already mentioned as almost peculiar to Italy. The type of the obverse, an ear of bearded wheat, as a symbol of Proserpine, is repeated on the reverse, but is there incuse instead of being in relief. The didrachms of the best period have on the obverse the head of Proserpine, or that of some other divinity, and on the reverse the ear of bearded wheat. Some of these are of extreme beauty. Of Posidonia, afterwards called Pæstum, there are archaic coins of the incuse class just mentioned, with the type of Neptune striking with his trident. The famous Sybaris, afterwards called Thurium, is represented, under its first name, by early didrachms with incuse reverses, probably of the sixth century B.C.; and, under its second name, by a very fine series of silver coins of about 400 B.C. Sybaris having been twice overthrown by the Crotonians, the new city Thurium was founded in its stead by a colony from Athens, B.C. 444. The later coins are chiefly didrachms, but there are not a few tetradrachms. Examples of both denominations are of very fine work. Some of the tetradrachms are superior in the quality of boldness, which is rare in Italy and Sicily, and equal in execution to any other coins of those countries. They are nearest, though yet inferior, to the finest coins of Greece and Asia. On the obverse they have the head of Pallas, with Scylla on the helmet, and on the reverse a bull butting.[1] Among the coins of Velia, which are principally didrachms, we notice many of beautiful work. Their common reverse-type, a lion seizing a stag, carries us to Asia, and reminds us that this town owed its origin to a colony of the Phocæans of Ionia, whose native place was taken by the Persians. This and similar types are almost wholly found on Asiatic coins, particularly those issued under Persian rule. They are evidently adopted from eastern symbolism, but with a change of meaning: the original signification seems to have been the strength of regal power, the later one, the strength of a divinity, probably always Hercules. It should be remembered that the difference of feeling among the easterns and the Greeks as to the kingly dignity would render a change necessary to preserve the religious meaning of these types. Passing on to the province of the Bruttii, we observe the coinage of that people, or of the province in general, to be fine in the three metals, though not of the best Italian style, the earliest pieces being probably not anterior to the time of Pyrrhus, King of Epirus. The money of Caulonia comprises early didrachms of the incuse class, with a type not yet satisfactorily explained, representing some divinity. The town of Croton is represented by a series of much interest. It commences with incuse didrachms of an early period. Some didrachms and smaller coins of a time somewhat later are remarkable for having on the reverse, instead of a repetition of the tripod, which is the type of the obverse, an incuse flying eagle. The didrachms of the period of good art are extremely beautiful. Two of their types are of especial interest; one represents Bellerophon on Pegasus, slaying the Chimæra; and the other portrays, on either side of the tripod, which is the most common type of the place, Apollo drawing his bow, and the serpent Python which he is about to destroy. The coin last mentioned exhibits very admirable work. The money of the Locri Epizephyrii is fine, but not of an early period: it probably commences just after the time of Pyrrhus. The town of Pandosia is represented by rare silver coins of great beauty. The series of Rhegium comprehends archaic tetradrachms, and others, as well as didrachms and copper pieces, of the best time, and of fine design and execution. The most interesting of these coins are some of the earliest. They are tetradrachms, having on the obverse a victor in a biga, and on the reverse a hare running. This is the type of tetradrachms of Messana of the same period so similar in work to these that they can only be distinguished from them with certainty by their inscription. The type ceases at Rhegium, but continues at Messana, and we perceive by the later coins of that place that the chariot is undoubtedly one drawn by two mules (ἀπήνη).[2] Aristotle, cited by Pollux, relates that Anaxilaus of Rhegium, having introduced hares into Sicily, and having conquered in the chariot-race of mules at the Olympic games, placed on the money of the people of Rhegium a mule-chariot and a hare.[3] The types relating to victories in chariot-races always refer to the success at the Olympic games of a citizen or tyrant of the place which struck the coin, as we shall be able to show. The pieces of Rhegium and Messana in question can only relate to a contest during the period at which the chariot-race of mules prevailed, that is, during the years from B.C. 500 to 448, inclusive. The earlier coins of Messana, and all of Rhegium of this type, must also be of a time when the two towns were under a united government. In the case of Messana, the coins follow a Samian influence, if not domination, since there is a piece of that town with the Samian types, which immediately precedes them.[4] These particulars all point to the time of Anaxilaus, tyrant of Rhegium, who first invited the Samians perfidiously to seize Messana, then called Zancle, about B.C. 494, and afterwards expelled them, and ruled the two cities until his death. His reign, reckoned from his accession at Rhegium, probably lasted from B.C. 494 to 476. This period corresponds to the style of the coins, which would point of itself to the earliest part of the fifth century B.C.[5] We may therefore consider that these coins of Rhegium, and the coins of Messana of the same time, bearing the same types, were issued by Anaxilaus after his victory at the Olympic games, of which Simonides sang the triumphal ode.[6] While we accept the explanation which Aristotle gives of the chariot, we cannot take that of the hare, since there is nothing the least resembling it in Greek numismatics. We would rather consider the latter type to be a relic of the old nature-worship, which was especially prevalent in Italy and Sicily, but of which the Greeks in Aristotle's time had but an indistinct knowledge. We will conclude this notice of ancient coins of Italy with those of Terina, of which the didrachms are of extreme beauty and delicacy. On the obverse they bear the head of a female divinity, called on a copper piece of the same place Pandina; and on the reverse, the figure of a local genius, or of the same divinity, usually, but not always, winged. In one case, the figure is represented filling a jar at a fountain issuing from a lion's head in a wall, and in another, resting seated on a jar, from which flows water; and it is worthy of note that, in the latter type, a flower springs up near the mouth of the jar. Pandina (Πανδινα) is probably a name of Hecate.

Greek Coins. Italy.

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[1] It has been suggested that the name Thurium, "impetuous" or "warlike," might be indicated by the bull, as a speaking type; but it is far more consistent with correct criticism to suppose that the latter refers to the rushing forth of a fountain, or rapid course of a river; a river, as we have seen is frequently represented as a bull, and a fountain might be with equal appropriateness.

[2] The ἀπήνη of the Olympic games was a chariot drawn by mules.

[3] Ἀναξίλας ὁ Ῥηγῖνος, οὗσης ἀγόνου τῆς Σικελίας τέως λαγωῶν, ὁ δὲ, εἰσαγαγών τε καὶ θρέψας, ὁμοῦ δὲ καὶ Ὀλύμπια νικήσας ἀπήνῃ, τῷ νομίσματι τῶν Ῥηγίνων ἐνετύπωσεν ἀπήνην καὶ λαγών. (Aristot. *ap. Poll.*, v. 75.)

[4] There are also coins of Rhegium with the Samian types, which were probably struck at the same period; whence it is reasonable to suppose that some of the Samians settled at Rhegium at the time of the taking of Zancle.

[5] The Syracusan decadrachms, called *damaretia*, which were struck in one of the three years B.C. 480–478, are certainly of better art than these coins of Rhegium and Messana; but this might be owing to the wealth and importance of Syracuse.

[6] Millingen's excellent paper "On the Date of some of the Coins of Zancle or Messana," in the *Transactions of the R. Soc. Lit.*, vol. i., part ii., p. 93 *et seq.*, is here our chief authority.

Greek Coins. Sicily.

(The most useful works on ancient Italian coins are Carelli's plates,[1] the account of the Æs Grave of the Kircherian Museum by MM. Marchi and Tessieri,[2] and Millingen's *Considérations*.[3])

The coins of Sicily properly follow those of Italy. They appear to have been issued during a period of about six centuries or a little more. The oldest cannot be carried further back than the commencement of the sixth century B.C., and the latest are Roman colonial pieces of the reign of Tiberius. The earliest coins are silver; the gold money commences with the period of the best art in Sicily, but is not common during the earlier part of that time; and the copper coinage probably begins during the fifth century B.C. The gold and the silver money cease at the subjugation of the island to Rome; but the copper continues later, some having been issued under the Romans. The latest coins are Greek imperial of Segesta and Roman colonial of Agrigentum, struck in each case under Augustus, and Roman colonial of Panormus, struck under Tiberius. In form the silver and copper pieces are compact and thick.

The types of Sicilian coins most resemble those of coins of Italy, especially of the south. They show the same partiality for representations of rivers, which are not unfrequently accompanied by their names. The most common and important device on the coins of the great towns, usually occurring on the reverse, and sometimes on the obverse, of the larger silver pieces, decadrachms of Syracuse, and tetradrachms and didrachms of that and other places, and on the reverse of some of the gold coins of Syracuse and its kings, represents a victor in a chariot-race. Its exact meaning never having been properly determined, we must give some space to its consideration. The same device, and others that belong to its class, occur on coins of cities out of Sicily; but as they are not so closely related to the Sicilian representation as the various types of that representation are to one another, we will not at present notice them. This device is found on coins of the Sicilian cities of Agrigentum, Camarina, Catana, Gela, Himera, Leontini, Messana, as well as Rhegium in Italy, with the same types as Messana, Segesta, Selinus, and Syracuse, and on coins of kings of the last town. The earliest and latest of these, of which the dates are most nearly known, were struck respectively in one of the years B.C. 480–478, and during the reign of Hiero II., King of Syracuse, B.C. 275–216. There are several types, which are of two classes. The first and more ancient class comprises all the early coins with this device, and closes at the commencement of the period of the best art, about B.C. 430; it is distinguished by the victor being a man. The second class extends through the periods of the best art, and of decline, to the time of the latest coin with the device; in it the victor is a goddess, and latterly usually Victory. On coins of one city, Selinus, of both classes, Apollo and Diana are represented together in the car; in the older ones Diana drives, in the later Apollo; and on tetradrachms of one type of Syracuse, a winged male genius acts as charioteer. The oldest coins of the first class generally have the type of a chariot drawn by two horses; others have a chariot drawn by two mules; and there are also trigæ and quadrigæ of horses. The later coins of the same class have almost always a quadriga of horses. On the earlier pieces the beasts are usually represented in slow action, probably through the unskilfulness of the artists; but on the later ones they are generally in rapid course. One of the metæ (*νύσσαι*) is sometimes seen beyond the chariot, showing that the critical time of the race is intended, when the driver had to avoid disaster by the adroitness with which he turned.[4] Victory hovers above, with a wreath, about to crown the charioteer, or as if intending to crown the horses. Beneath, in the exergue, on the later coins, we notice symbols, usually dolphins or other marine animals, or objects proper to the sea. On the coins of the second class, the chariot is always a quadriga, either in rapid course, or proceeding slowly as if in triumph. The place of the charioteer is taken by a goddess, as already mentioned, who is either a divinity of the place, as Proserpine at Syracuse and Segesta, and Minerva at Camarina, or Victory; and, except in the last case, Victory hovers above with a wreath, about to crown the victor. As we have already mentioned, on coins of Selinus, Apollo and Diana are represented in the car together, the former driving on those of this class; and on coins of Syracuse, a winged male genius is charioteer: these are exceptional examples. In the exergue are either marine objects or prizes, but not the wreath, with sometimes at Syracuse the inscription ΑΘΛΑ, leaving no doubt as to their meaning. These prizes are a suit of armour on coins of Syracuse, and two jars on those of Camarina.

These types plainly refer to victories in the chariot-races of public games which had reflected honour upon the great towns of Sicily. From the marine symbols, we should infer that they were celebrated on the sea-shore, or were in some manner connected with the sea. The religious character of the types of Greek coins shows that these must have been sacred games; and the substitution of divinities for the charioteers proves that they were held in the highest reverence. In the *Iliad*, when the divinities personally assist the heroes, as especially where Minerva acts as charioteer to Diomed, it is only on some occasion of the greatest importance, in accordance with the Horatian maxim. Usually they aid their favourites less directly, as at the games at the funeral of Patroclus, where the poet makes Eumelus about to succeed through the help of Apollo, until Minerva secures the victory for Diomed. In both cases the idea is the same as that intended to be conveyed by the later types of the coins. It might be contended that games held in such high honour could scarcely have been local celebrations at the towns on the money of which they are commemorated; but there is direct evidence to show that they were not such. One of the metæ is represented on coins of Catana, of about B.C. 380, and on others of Gela, of about fifty years earlier, and is in each case an Ionic column,[5] although the treatment of the chariot and the general style is far different. The types, therefore, refer to chariot-races of four different kinds, celebrated at games held in the highest reverence. To no games will these particulars so well apply as to the Olympic. They were the most revered and famous of all the Greek games, being the chief of the four called sacred; and at them, during the periods at which the various types first occur, were held races of the very four kinds which they represent, the chariot-race of mules having lasted, as previously noticed, only fifty-three years, a period including that during which the first coin relating to such a contest was struck. A victory at the Olympic games was held to be no less glorious to the city of the victor than to himself. It is probable, indeed, that the highest honours were paid to the victor in the foot-race, after whom the Olympiad was distinguished; but there is no doubt that success in other contests, and especially in the chariot-race, was considered as not much less glorious. Nothing, therefore, could be more proper than the commemoration on coins of victories in the Olympic chariot-race; and we have only to inquire whether the cities of Sicily with types relating to such races were successfully engaged in that contest. The remaining odes of Pindar, which are of the very period of the earlier of the coins we are considering, give no doubtful answer. Fourteen of these odes relate to the Olympic games, and of these, again, six celebrate success in chariot-races, every one of which was gained by a Sicilian,—two by an Agrigentine, two by a Camarinæan, and two by Syracusans,—all of cities which struck coins with the chariot-type. If we look at the lists which have been made of victors in the Olympic games mentioned by ancient writers, we perceive that not only these cities, but others of Sicily of which the coins have chariot-types, were successful in the Olympic chariot-race or at other contests of those games.

If any doubt remained as to the correctness of this explanation, it would be removed by the direct statement of Aristotle, already noticed, that Anaxilaus, tyrant of Rhegium, placed the type of a mule-chariot on the coins of that place when he had been victorious at the Olympic games; and that of Plutarch, that Philip II. of Macedon commemorated his success in the Olympic chariot-race by placing the representation of a chariot on his money. The former story we have seen to be confirmed by coins of Rhegium and Messana, and the latter is shown to be correct by the representation, on the reverse of Philip's gold pieces, or staters, of a victorious biga, a type not seen on the coins of earlier kings of Macedon.

This explanation of the chariot-type in the case of Philip's staters leads us to the discovery of the true meaning of a kindred device, occurring on his coins and those of several Greek cities. Philip is also related to have gained the prize in the horse-race at the Olympic games; and, accordingly, the common reverse-type of his largest silver coins, which are tetradrachms, represents a horseman holding a palm. The palm is not the only indication that a race is here referred to; for if we compare this type with the less common one representing a mounted traveller, probably some hero, we observe that the rider in the former case is smaller than in the latter, and the horse perhaps larger. There can, therefore, be no doubt that Philip commemorated his victory in the horse-race, as he did that in the chariot-race, on his coins. This result leads us to examine the common reverse-device of the didrachms of Tarentum, which represents a horseman, naked or armed, generally either crowned or about to be crowned with a wreath by Victory, flying above him, or crowning himself, or crowning his horse.

[1] *Francisci Carellii Numorum Italicæ Veteris Tabulas* ccii., edidit Cœlestinus Cavedonius, 4to, Leips. 1850 (best ed.).
[2] *L'Aes Grave del Museo Kircheriano ovvero le Monete Primitive de' Popoli dell' Italia Media* [Giuseppe Marchi e Pietro Tessieri], Roma, 1839.
[3] *Considérations sur la Numismatique de l'Ancienne Italie*, par James Millingen, 8vo, Flor. 1841. Suppl. 1844.
[4] Soph., *Electr.* 720–722 and 743–748. The whole of this description, the *locus classicus* on the Greek chariot-races, deserves careful study in connection with the coins, although it must be remembered that it relates to the Pythian games. Comp. Hor. *Carm.*, lib. i., od. i. 3–6.
[5] It would seem, from the description of Sophocles (*Electr.*, loc. cit.), that the metæ at the Pythian games were objects like posts, perhaps columns.

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The importance of the horse is shown not alone by his being crowned by the rider; in another type he is embraced, or at least welcomed, by Victory standing to receive him, as if after a race; and again, in another, a small figure, apparently a genius, raises one of his fore-feet and examines the hoof, as if to extract a stone. Another type shows two horses, the rider of one of which leads the other. In the exergue of these coins there are symbols, often of a marine character. All these representations evidently relate to games held in high honour, at which the horse-races were of two kinds, —one the usual contest with single horses, the other that at which every rider had two horses, one of which he rode while leading the other. There must also have been some connection with the sea. Here, as in the case of the chariot-race, the particulars entirely agree with the Olympic games, at which there were the two kinds of horse-races represented—the common one, and that with two horses. As if to remove all doubt, a similar type to those of Tarentum occurs on the coins of Syracuse and Leontini smaller than the tetradrachms. In the case of the former town, a rider is represented on the reverse of didrachms, drachms, and hemidrachms, and in that of the latter, of didrachms and drachms; in each case of the earlier period. In one of the Syracusan examples, Victory flies above the horseman, while in the exergue there is a marine monster; two particulars which complete the parallel with some examples of the chariot-type on coins of the same place. If the explanation of the chariot-type be correct, it cannot be doubted, especially when we recollect the minute agreement in the instance last mentioned, that the similar type which we are considering must be explained in the same manner. It should, moreover, be borne in mind that the two types occur in Philip's coinage, with strong evidence of their meaning, and that it is therefore probable that they have the same signification on the other coins mentioned above; in each case referring to two kinds of contests at the Olympic games. The gold coins of Cyrene, which we have not yet mentioned, have the two types. They present no difficulty. The chariot is always a quadriga, bearing in the earlier examples a figure seeming to represent a common charioteer, but in the later, a Victory driving. The horseman has, in one instance, the traveller's hat, or causia, hanging from his neck behind; and here he might possibly be a hero, as on coins of Macedonian kings. As in the case of the Sicilian cities, we find from ancient writers that Cyrene was successful at the Olympic games. It is probable that, at a comparatively late period, perhaps from the early part of the third century B.C., these types lost their proper meaning, and were no longer used with reference to any victory of the city or king issuing the coins bearing them, but were copied in a careless manner from the earlier coinage, or continued with a kind of heraldic intention.

Some objections which are likely to occur to any one considering this question may be here noticed. A similar explanation of the chariot-types was offered by the older writers, and has been abandoned by numismatists, except in the case of Philip's staters. Why, it may be asked, has their explanation fallen to the ground if it be near the truth? We reply, because it was founded on bad criticism, and uncritically developed. It is no matter for surprise that the earlier numismatists should have supposed that these types referred to famous games, for they were always striving to discover some reference to whatever was celebrated in ancient times. Thus far they happened to be right; but the next step led them into error, for, with their accustomed carelessness in such matters, they fixed in any case upon that one of the four sacred games to which the character of a particular device seemed at first sight to point. Such mere guesses, supported by no sound reasoning, were often necessarily erroneous, and the explanation fell into contempt. Nothing but a knowledge of the religious meaning of the types of Greek coins, and of the appropriateness of all their details, could establish a correct explanation. Another objection wears at first sight a more serious aspect. It seems unreasonable that the Olympic games should be commemorated on coins struck in Sicily, in Italy, in Macedonia, and in the Cyrenaica, and not on coins of Greece Proper. We must remember, however, that an Olympic triumph would have been esteemed of far more importance in remote places than those near the scene. The difficulties of the voyage or journey, the long absence of the competitors, and their great expenses, would, in the case of distant cities, forbid any but the most wealthy from engaging in the contest, and raise public expectation to the highest pitch while expecting the event. These conditions would, indeed, scarcely be those of the kings of Macedon; but they had a special motive for feeling pride in an Olympic success: their country was out of the limits of Hellas, and as none but Greeks could join in the great contest, it was only by proving a Greek ancestry that they obtained, with difficulty, this privilege. The Greeks of Italy, of Sicily, and of Africa, may have felt a similar pride in being able to contend, while their neighbours, often not only little inferior to them in civilization, but far excelling them in power, were rigorously excluded.

Greek Coins. Sicily.

In adopting the explanation given above of two classes of types of Greek coins, we must be careful to avoid an error into which the earlier writers fell. It would be natural to suppose that the coins bearing these types celebrate directly certain victories, or even victors, at the Olympic games, but the principles which regulated the choice of types forbid such a conclusion, while the coins present no direct indications of any relation to individual persons, but in the later period the very contrary. The types were first adopted on occasions at which the city or sovereign acquired distinction at the Olympic games, but not with the intention of a direct historical or personal reference, although there is necessarily such reference of an indirect character. The nature of the difference is well explained by the absence, as far as we know, of any types referring to the foot-race, the successful contender in which was the especial Olympic victor, or to other contests besides the horse-race and chariot-race. In these other contests the victor was personally engaged, whereas in the chariot-race and horse-race this was not necessarily the case, and apparently very unusual; indeed, as to the latter, the evident light weight of the riders represented on the coins proves that, at the period to which they belong, the owners could not have generally ridden their horses. The victors could not, therefore, be directly commemorated by these types. It would be interesting to pursue this inquiry, but we cannot do so in the present article. We would, however, in conclusion, caution students against hastily supposing some apparently similar types to have the meaning of those we have explained. Investigations of this kind must be prosecuted with the utmost care, and coins or types must never be considered singly, except after every effort has been made to gain the illustrative light afforded by similar examples.

The inscriptions of Sicilian coins, particularly the older, are interesting with respect to palæography and for their orthography. We may especially point out the inscription AKPAΓANTOΣ, written in the boustrophedon manner on tetradrachms of Agrigentum of the best period. Other instances will be mentioned when we speak of the coinage of the principal towns. We have already noticed the art of Sicilian coins, which may be regarded as on the whole more typical of the western school than that of the coins of Italy. The denominations are, in the case of gold, the same as those of Italy, —Greek in origin, though not wholly identical with any Greek system; in the case of the silver, purely Greek; and in that of the copper, Italian. The silver coins are of very heavy Attic weight, excepting only those of Zancle before it was called Messana, and the earliest of Himera, both which follow the Æginetan system. The principal silver coin is the tetradrachm, which takes the place of the didrachm of Italy. Although the copper money is adjusted to the native Italian system, its art, as with the rest of the coinage, is Greek.

The first coins to be noticed in the series of Sicily are those of Agrigentum. They include gold as well as silver pieces of the period of good art. The most remarkable of the silver are tetradrachms, some of which have on the obverse two eagles devouring a hare, and on the reverse a successful chariot at the Olympic games driven by Victory; while others, as well as didrachms, have on the obverse an eagle standing, and on the reverse a crab. The copper coins are on the Italian system: many of them are of the good period, and of good work. The type most worthy of note is the head of a river-god, with the name Acragas, which was that of the river of the town. The success of Agrigentum at the games is attested by Pindar; while Virgil (*Æn.* iii. 704), Gratius (*Cyneg.* 526), and Silius Italicus (*Punic.* xiv. 208-210), mention its ancient renown for horses. Its lofty site (*arduus Acragas*), overlooking the sea, and on the bank of the stream of the same name, makes the eagles, the crab, and the river, appropriate devices, showing that Greek types have a local fitness, while chosen with a religious intention.

The money of Camarina is of especial beauty and interest. The fifth of Pindar's Olympic odes, that to Psaumis the Camarinæan, B.C. 452, affords an excellent commentary upon it. The earliest coin we know is a didrachm of about this time; whereas there are many pieces of from fifty to a hundred years earlier of most of the other important cities of Sicily. Camarina, however, was then but lately inhabited (*νέοικον ἕδραν*), having been recently twice devastated by the Syracusans. If there be any older coins, they are probably of a different type. This has on its obverse a helmet upon a round shield, and on its reverse a pair of greaves, between which is a dwarf palm (*Chamærops humilis*).[1] The arms are perhaps those of Minerva, kept here, as Virgil (*Æn.* i. 16) and Ovid (*Fast.* vi. 46) say the arms of Juno were at Carthage; and the palm might represent the sacred grove (*ἄλσος ἀγνὸν*) in which the temple of the goddess probably stood. This piece is followed by tetradrachms and didrachms of the best period and of most beautiful work, varying a little in their style. The tetradrachms have on the obverse

[1] *Oxford Essays*, 1857, "Sicily," by M. E. Grant Duff, p. 75.

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the head of Hercules in the lion's skin, and on the reverse Minerva, as a victor at the Olympic games, in a quadriga, a type of which we have already spoken. It was Minerva, protector of the city (πολιάοχος Παλλὰς) whose sacred grove was made more illustrious by the success of Psaumis. The didrachms have on the obverse the head of a river-god, portrayed as a young man with small horns, and with his hair wet. Of the two rivers of Camarina, the Oanus and the Hipparis, the latter is here represented, for in one case the name is given on the coin. Pindar seems likewise to show the same preference; for while he merely mentions the Oanus (ποταμὸν . . . Ὦανον), he speaks of the sacred channels in which the Hipparis watered the city (σεμνοὺς ὀχετοὺς, Ἵππαρις οἵσιν ὕδρει στρατὸν). On the reverse the nymph Camarina (Ὠκεανοῦ θύγατερ . . . Καμαρίνα) is seen carried across her lake (ἰγχωρίαν . . . λίμναν) by a swan swimming with expanded wings, while she aids it by spreading her veil in the manner of a sail. Some of these didrachms have on either side, around the chief device, fresh-water fishes. The copper coins of Camarina are on the Italian system.

The series of Catana comprises fine archaic tetradrachms and others of the time of the best art, which are handsome, though mannered. The reverse-type of the latter is a victor at the Olympic games in a quadriga, passing one of the metæ, which is a column of the Ionic order. Gela is represented by coins in the three metals. The archaic tetradrachms and didrachms must be especially mentioned. The former have on the obverse the fore-part of the river-god Gelas, whence the city took its name—

"Immanisque Gela fluvii cognomine dicta"

(*Æn.* iii. 702), as Agrigentum did from the Acragas, and Camarina from its lake. The Gelas is represented as a bull, having the face of a bearded man. On the reverse is a victorious biga at the Olympic games, in some examples represented passing a meta, which is an Ionic column, and resembles that on coins of Catana. A tetradrachm of the later portion of the time of good art, with the types of the fore-part of the Gelas and the victorious chariot, here a quadriga, is remarkable for having above the latter a bird, doubtless an eagle, taking the place of Victory. A tetradrachm of the commencement of the period of good art, and of the highest western style, characterized by a slight severity of treatment, has on the obverse the head of the Gelas, as a young man horned, surrounded by three fresh-water fishes; and on the reverse Victory in a biga, with a wreath above. The accompanying inscription is ΓΕΛ-ΩΙΟΝ. Some of the copper coins are beautiful, but not of the finest style. The money of Himera is of great interest. The earliest pieces are didrachms, which, like the series of Zancle, follow the Æginetan talent. No other Sicilian cities are known to have struck coins on this weight. The oldest didrachms of Himera, which probably commenced in the sixth century B.C., bear on the obverse a cock, and on the reverse an incuse type. They are succeeded by archaic tetradrachms, which bear on the one side a victorious chariot, and on the other a nymph sacrificing, near whom a little Pan, or Paniscus, stands beneath the stream of a fountain issuing from a lion's head in a wall. The fountain no doubt represents the hot spring of the place, from which it was afterwards called Thermæ. Leontini is chiefly represented by archaic tetradrachms and didrachms; but there are a few tetradrachms of the early part of the time of good art. The type of the chariot at the Olympic games occurs on these coins, of both periods. The series of Messana is one of particular value. It commences when the town was called Zancle, or, as it is written on the coins, Dancle, with early drachms and smaller pieces of the Æginetan weight, and of very archaic work. On the obverse is a dolphin, and around it a sickle; and on the reverse is a shell in the midst of an incuse pattern. The place is said to have received its name on account of its resemblance in form to a sickle (ζάγκλον, or ζάγκλη), like the town of Drepanum, or Drepana, in Sicily, and probably the promontory of Drepanum of the Peloponnesus. If there were no religious meaning attached to these names, this early design of Zancle would be an instance of what is termed a speaking type. It is more reasonable, however, to suppose that in each case there was a primary religious meaning in the names, and indeed later writers say that the sickle of Saturn was buried here, and at the Sicilian Drepanum, the descriptive character offering a secondary meaning. Next to these first coins of Zancle may be placed, as the oldest piece of the Attic weight, a tetradrachm with the Samian types,—a lion's scalp on one side, and on the other the head of a bull, and bearing the inscription ΜΕΣΣΕΝΙΟΝ (for Μεσσανιων). This coin was doubtless struck during the rule of the Samians, who took the place about B.C. 494, at the instigation of Anaxilaus, tyrant of Rhegium, by whom they were subsequently expelled. (*Thucyd.* vi. 4.) The next pieces are the earliest of those which have on the obverse a chariot drawn by two mules, and on the reverse a running hare. They most closely resemble coins of Rhegium, with the same devices, and must be assigned, like them, to the rule of Anaxilaus. As we have already mentioned, the period at which this tyrant governed the two towns is thus indicated, particularly as these types cease in the coinage of Rhegium, although they continue at Messana, some of the tetradrachms bearing them being of the period of fine art.[1] The copper coinage is of good work. When the town had been seized by the Mamertini, its name was changed to theirs, which is accordingly borne by the later coins, which are of copper. They are good, but not of the best style. Naxos is represented by handsome archaic tetradrachms and others of the fine period, and by smaller silver pieces, chiefly of the earlier time.

Greek Coins. Sicily.

There are some coins of the city of Panormus, but most of those which have been classed to it are of the Carthaginians, issued both in Sicily and Africa. Nothing is more probable than that many of these pieces were struck at Panormus, but there is no means of distinguishing any such, and if there were, the mere fact of their having been issued at the place would not justify us in classing them to it. The Carthaginian coins of Sicily may be best noticed after the Greek coins. Segesta is represented by tetradrachms and didrachms of the archaic and of the good period. One of the tetradrachms of the early part of the latter time has on the obverse the Olympic victorious quadriga, driven by Proserpine, who carries ears of bearded corn, while Victory flies above, about to crown her. The reverse-type represents a hunter, that is, some divinity or mythical hero in that character.

The series of the city of Selinus next demands notice. The first coins are didrachms, bearing on the obverse a leaf, and on the reverse an incuse square, either having several divisions, or else containing a repetition of the leaf. The representation of the leaf is not, either on these or later coins, very exact. The city and its river no doubt derived their name from the plant σέλινον, the leaf of which must be here intended. There is some difficulty as to its identification; for in this case, as in those of many other natural objects, the Greeks may have given the same appellation to very different things. The plant sacred at Selinus appears to be, as Colonel Leake supposes, wild celery (*Apium graveolens*);[2] but it does not follow that that of the same name with which the victors at the Isthmian and Nemean games were crowned was really the same.[3] Tetradrachms of a later time, either of archaic style or of that of the earliest part of the period of good art, have devices of more than usual interest. The obverse bears a biga with Apollo and Diana, the latter of whom drives,—a type doubtless referring to the Olympic games; and the reverse exhibits a river-god, the Hypsas, sacrificing at the altar of Æsculapius, while a wading bird is sometimes seen behind him, as if departing. The latter subject appears to allude to the draining of the marshes into the river, by which the place was rendered more healthy. A tetradrachm of the best Sicilian style is important in connection with the opinion we have put forward as to the meaning of the chariot-types. It has on the obverse a quadriga, with two personages, doubtless Apollo and Diana, the former of whom appears to be driving; above them is a wreath, and below an ear of bearded wheat,—the former plainly indicating a victory, the latter connecting the type with a Syracusan one of the same period relating to the Olympic games. The reverse represents the Hypsas sacrificing, as usual.

The illustrious city of Syracuse is worthily represented by its coins. Its early and long-continued greatness in commerce and in arms, its luxury and its love of the arts, are attested as fully by these monuments as by the voice of history. The best do not indeed ever display the breadth and grandeur, and rarely the simplicity, that characterize the highest examples of the medallic art of Greece and her Asiatic colonies, but rather err in an excess of richness and a use of tricks of art; yet the intrinsic beauty of many, and the fine execution of almost all, command great admiration, while the historical value of the series gives it an additional interest. The system of the gold coins of the Syracusans, like that of those of the Greek cities of Italy, is fundamentally on the Attic standard, but presenting some remarkable differences. Thus, although there are gold drachms and hemidrachms, there are also pieces respectively

[1] On the early coins of Messana compare Millingen's paper in *Trans. R. Soc. Lit.*, vol. i., pt. ii., pp. 93, *et seq.*; and p. 363, *supra*.

[2] *Numismata Hellenica*, "Sicily," &c.; *Oxford Essays*, 1857, "Sicily," p. 79.

[3] Plutarch narrates a story of Timoleon which illustrates this question, relating that when he was marching from Syracuse to encounter the Carthaginians, as his soldiers were going up a hill, on the other side of which they expected to see the enemy, they met mules carrying parsley (σέλινα). This they took as a bad omen, because of the Greek custom to crown the sepulchres with parsley, which occasioned the proverb, of one dangerously ill, that he should have parsley. But their leader encouraged them by saying that Fortune had brought them their crowns before victory, because the Corinthians held the crown of parsley sacred, and then decorated with it the victors at the Isthmian games. (Plut. *Timoleon*, cap. xxvi.)

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as heavy as one and a half of each of these denominations. The oldest examples are of the early part of the period of good art, and therefore date from about the middle of the fifth century before the Christian era; and the latest probably immediately precede the reign of Agathocles (B.C. 317), the first tyrant whose name we find on the coins. There are some of these pieces which show marks of decline, but the greater number are of good work. One of the finest has on the obverse a head of Apollo, and on the reverse one of Diana, very differently treated,—the former having an ideal character, but the latter resembling a portrait. Other coins present on the obverse heads of the young Hercules and of other divinities, while the most important reverse-type is a victorious biga. The silver coinage of Syracuse, which follows the Attic talent, presents many denominations. The decadrachms, though rare, are more common than those of any other city. The tetradrachms are extremely numerous, and evidently formed, at almost every period until about the time of Agathocles, the bulk of the silver coinage, the smaller denominations being of less frequent occurrence. The earliest coins are tetradrachms and didrachms of very rude work, which may be assigned to the later part of the sixth century B.C. The tetradrachms bear on the obverse a charioteer in a biga, and on the reverse an incuse square of four divisions, having in the centre a female head, probably that of Proserpine. The didrachms have a rider on the obverse, and the same reverse-types as the tetradrachms. A little later we find coins of much better execution, having a female head on the obverse, with dolphins, usually four in number, around it; and on the reverse Victory above the chariot or the horseman. Next in time to these are the famous decadrachms, believed to be the coins known as *damaretia*, struck by Damareta, wife of King Gelon, on receiving a present of a hundred talents of gold, which the Carthaginians gave her when she had negotiated peace for them, after their defeat by her husband at the battle of Himera. As this battle was fought in the year B.C. 480, and Gelon died B.C. 478, the date of these coins is very nearly fixed, and may be considered to be B.C. 479. They afford an example of the highest archaic style, a style not without its excellence and promise. The resemblance to Egyptian art is most remarkable, and far greater than we observe in the money of Greece Proper. The obverse bears a female head, probably that of Proserpine, bound with a wreath; it occupies a circle, indicated by a fine line, without which are four dolphins, as though swimming round. The reverse-type represents a chariot, apparently drawn by three horses, in slow action, and driven by a man. Victory flies above, and below is a lion running. The style of the face of the goddess, with the slightly rounded nose, the eye as if seen in front, and the placid expression, no less than the treatment of the horses, at once recalls to one's mind the colossi and battle-scenes of the temples of Egypt. There are tetradrachms of so exactly the same work as these larger pieces that they must have been issued with them. After this time we perceive a rapid change to a much freer style, but yet one that already shows mannerism. The hair of the goddess, now undoubtedly Proserpine, is either partly covered with a kind of bag, or is variously arranged, sometimes in almost a fantastic manner; and the dolphins around are less regularly placed than before. The period of good art may be considered to begin about B.C. 450, and to terminate with the commencement of the tyranny of Agathocles (B.C. 317). The length of this time is partly due to an accident which happened here towards its close—the introduction, when medallic art was fast declining, of coins with the types and style of those of Corinth, where that art had but little decayed; so that there was a kind of recovery, very unusual in ancient money. At the commencement of the period of the best art, we observe some admirable tetradrachms, which, for the beauty of the face of Proserpine, the treatment of her hair, and the vigour shown in the drawing of the horses, now and always henceforward on the civic coins represented at full speed, are in their class quite unexcelled. The finest of these coins known to us is one in the British Museum. It has on the obverse a most beautiful head of Proserpine surrounded by three dolphins, and on the reverse a victorious quadriga, driven by a bearded charioteer. Victory hovers above, holding in her right hand a wreath, and in her left a label bearing the inscription ΕΥΑΙΝΕΤΟ, supposed to be the name of an artist. The names of artists begin to appear on these coins about this time; and the distinction given to this word is by no means a proof that it is not one. Another, but little later, has on the obverse a head of Proserpine with ears of bearded wheat in her hair, and on the reverse a quadriga driven by a winged male genius, while Victory hovers above crowning him. On the obverse is ΕΥΜ, the beginning of an artist's name, and on the reverse ΕΥΘ, the beginning of the name of another artist, showing that different hands were employed to design the two sides. Several coins, still somewhat later than this, have on their reverse Proserpine, with a flaming torch in her hand, driving the victorious quadriga. One of these has for the obverse-type a helmeted head of Minerva. To the same time belongs a tetradrachm with a very beautiful head of the fountain-nymph Arethusa, whose name is sometimes written above in the form ΑΡΕΘΟΣΑ, as in Lord Northwick's admirable specimen, which has also the name of the artist, ΚΙΜΩΝ, on the fillet. The head is represented facing, but somewhat turned to the left, with the hair loose and as if wet, though skilfully arranged. The reverse bears Proserpine in a victorious quadriga. The name of Cimon also occurs on more than one of the decadrachms of the fine period, which we might otherwise have supposed to have been struck a little later. There may, however, have been two artists of the same name, or one may have worked at different periods of his life in styles varying as much as these. The later decadrachms are not, however, like the earlier, all of the same time; for there are some of an inferior style, which must be referred to a lower date. All were, however, probably struck during the tyranny of the first Dionysius (B.C. 405–368). Their obverse-type is a head of Proserpine, with the hair variously arranged, sometimes partly contained in a bag of net, sometimes bound with corn leaves, and surrounded by four dolphins. The reverse displays the same goddess in a victorious quadriga at full speed, while Victory above is about to crown her; and the reward, a suit of armour, sometimes with the word ΑΘΛΑ, is seen below. These coins have been commonly considered the finest in the Greek series; but the best of them are excelled in design and in execution by tetradrachms of the same place, and even these cannot be compared to the productions of the pure Greek school, as we have already endeavoured to show. There are other tetradrachms, besides those already mentioned, of about the time of these decadrachms; and some of a later period and inferior work, which are probably of the reign of Dionysius II., and of the republic established by Dion and overthrown by the tyrant. All these have types very similar to those of the decadrachms. The figure in the quadriga of the latest is, however, Victory. After these it is most reasonable to place those didrachms and smaller coins, which, although of Syracusan fabric, have in the former case wholly, and in the latter partly, Corinthian types. They are of good work; and the didrachms so closely resemble those of Corinth, that their issue can only be explained by the supposition of some extraordinary influence on the part of the parent city. This condition is perfectly fulfilled by what occurred at Syracuse on the final overthrow of the second Dionysius by Timoleon the Corinthian (B.C. 344). The depopulated state of the city accounts for the inferiority of those coins which we suppose to have been struck a little before this event; while a large issue of Corinthian coins at Syracuse would agree with the policy of Timoleon. He replenished the population with a body of Corinthian colonists, and sold the houses to them, depositing the proceeds in the treasury; and in accordance with his endeavours to connect the town as much as possible with Corinth, he would naturally, on issuing a new coinage from the sum thus obtained—said to have been a thousand talents (of silver)—have adopted the Corinthian types. There is a kind of hybrid coinage, half Corinthian and half Syracusan in character, which probably succeeded this, and lasted until the reign of Agathocles. The copper coinage of Syracuse anterior to Agathocles does not commence before the period of good art. It is on the Italian system, often of fine design and work, and well deserves the most careful study.

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The regal coins of Syracuse are of far inferior interest to those struck in the name of the people. Some of them are beautiful, but none in the highest style of Sicilian art. The series is important on account of the weight of the silver pieces after the time of Agathocles. For these the Ptolemaic talent seems to have been used, their weights being in accordance with it; while the treatment of the portraits is similar to those of the Greek kings of Egypt. Of Hiero II. there are octodrachms, of Queen Philistis tetradrachms and smaller pieces, and of Hieronymus pentadrachms. It is to be observed that the drachms of Philistis have a low Attic weight. It is possible, from the rarity of these silver coins, that they were struck rather as medals than to form the bulk of the coinage. The money of Agathocles is in gold, silver, and copper; that of Hicetas in gold; and that of Hiero II. and Hieronymus, again, in the three metals. Queen Philistis is only known from the coins and an inscription. She must have been the wife of Hiero II. towards the end of his reign, or of one of his sons. Her coins have fine though mannered designs; that of the obverse being her veiled head, and that of the reverse a victorious chariot. The later Gelon is probably a son of Hiero II., of that name, who may have been admitted to some share of regal power.

The town of Tauromenium, represented by five pieces in the three metals, closes the series of those Greek cities of Sicily, which are of high numismatic interest. We must, however, mention the main characteristics of the true Siculo-Punic coins—that is, those

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actually struck by the Carthaginians in Sicily. It has been usual to place together a large class of Græco-Punic coins, on account of their general similarity. A careful examination, however, shows that they must be separated into two distinct divisions, representing the coinage of the Carthaginians in Sicily and in Africa, as Mr Burgon pointed out in his catalogue of the Thomas Collection. These classes are mainly to be distinguished by their weight, the Sicilian coins being adjusted to the Attic talent, like those of the Greek cities of the island, while the African follow the Phœnician talent; but there is also a general difference in the types and style, which in the former are far more Greek than in the latter, in which Egyptian, or at least African, characteristics may be perceived. The Siculo-Punic coins are in silver and copper, for there are no gold pieces belonging undoubtedly to this series. Tetradrachms are the most numerous of the silver pieces. The most frequent types are, for the obverse, the head of Proserpine, and for the reverse a horse or horse's head, both, especially the horse, being sometimes accompanied by a date-palm. The horse was probably sacred at Carthage, and thus came to be the favourite symbol of the city. In late times the head appears to have become the prevailing form of the symbol. It may be worth while to remind the reader that both Virgil[1] and Silius Italicus[2] mention the digging up of a horse's head—the symbol, says the former, of the future nation—at the foundation of Carthage; and that the form of this tale given by Eustathius is still more illustrative of the coins. The last writer relates that the founders having discovered the head of an ox, took it as a bad omen, and left off digging; but commencing again about a cultivated date-palm, like that of the coins (*φοίνικα πεφυτευμένον*, as distinguished from a wild one), found the head of a horse.[3] This version of the story may be the origin of the combination of the horse and date-palm upon the Carthaginian money. We may also notice that there are Siculo-Punic tetradrachms with the head of Proserpine and a victorious quadriga, struck in imitation of coins of Syracuse of the same denomination.

(The principal work upon the Sicilian coinage is that of G. L. Castelli, Prince of Torremuzza, which, although published towards the close of the last century, has not yet been superseded.[4])

The islands near Sicily struck copper coins which are often singular, and always of some interest. Those of Cossura are Phœnician, with an Egyptian character; those of Gaulos are Greek and Phœnician; and those of Melita, Phœnician, showing both Egyptian and Persian influence. Of Lipara there is heavy copper money on the Italian system, having on the obverse a head of Vulcan, and sometimes on the reverse a figure of the same divinity seated, holding a hammer, and a vase which he seems to have just formed.

The Tauric Chersonese.

In the Tauric Chersonese there are interesting coins of the city of Panticapæum, the modern Kertch, in the three metals. Their obverse usually bears the head of a Pan, and their reverse a gryphon, or its head or fore-part. The money of European Sarmatia, of Dacia, and of Upper and Lower Mœsia, is chiefly copper of the Greek imperial class. The few coins of earlier times are generally of a coarseness not far removed from barbarism. In European Sarmatia we may notice the autonomous and imperial pieces of Oebiopolis, and in Dacia the series bearing the name of the province. The Roman colonia Viminacium, in Upper Mœsia, is represented by numerous coins of a late time. Of Istrus, in Lower Mœsia, there are didrachms and drachms having a strange type on the obverse, representing two beardless heads side by side, the one upright and the other upside down. On the reverse is an eagle devouring a fish. The former type has not been explained: it probably relates to some Greek myth. The style of those coins, it may be noticed, is in general fair, though it sometimes approaches to barbarism. There are abundant Greek imperial coins of Marcianopolis and Nicopolis; while Tomis, the place of Ovid's banishment and death, is not unrepresented in this class.

Thrace.

The coins of Thrace are of high interest. The oldest are probably of the sixth century B.C., and there are others of all subsequent times, both while the country was independent and while it was subject to the Romans, until the cessation of Greek coinage. Some of the best period are of the highest artistic merit. So long as they maintain any general distinctive peculiarities of fabric and design—that is, from their commencement until the age of Philip—the Thracian coins resemble those of Macedon. They also follow the same talent, that of Macedon, commonly called the Alexandrian or Ptolemaic. The heaviest tetradrachms are the earlier, which weigh about 232 grains: those issued at later times are generally much lighter. The money of Abdera comprises tetradrachms and smaller coins of the period of archaic and fine art. The principal type is a seated gryphon. Ænus is remarkable for the great beauty of some of its coins. These are tetradrachms of the earliest part of the time of the best art. They bear on the obverse a head of Mercury, facing, in his cap, and on the reverse a goat. The broad, free treatment of the head cannot be sufficiently praised; and it is worthy of remark, that it is here far more effective than the later and artificial style. There are drachms of a period subsequent to that of these coins, which enable us to make this comparison. The money of the ancient city of Byzantium commences with early tetradrachms and smaller coins, having on the obverse a bull above a dolphin, and on the reverse an incuse square of four divisions. Tetradrachms of the late part of the time of good art, bearing the head of Ceres veiled, and with corn in her hair, on the obverse, and Neptune seated, on the reverse, should also be noticed, as well as the long series of copper coins issued under the empire. Of Cosa there are Græco-Roman aurei, which were probably struck by Brutus during the short time that he maintained himself against the triumvirs. They bear on the obverse an eagle holding a wreath in one claw, and on the reverse a figure in a toga between two lictors, with the Greek inscription ΚΟΣΩΝ. There is sometimes in the field of the reverse a monogram of the letters L B, which is supposed to indicate the name of Lucius Brutus, whom we know to have struck Roman money with the more famous Marcus Brutus. The Roman colonia of Deultum is represented by many coins; and the city of Hadrianopolis by a long series, comprising fine pieces. Of Maronea, anciently famous for its wine, there is an interesting series of coins, beginning with very early drachms. After these we notice tetradrachms of the fine period, having on the obverse a horse, and on the reverse a vineyard, conventionally represented by a vine in a square. There are also large tetradrachms of a late time, with, on the one side, the head of an androgynous Bacchus, and on the other the standing figure of a young Bacchus. The Greek imperial coins of Pantalia and Perinthus are worthy of notice. Among those of the latter town we may mention very fine pieces of Antoninus Pius and Severus, and large coins, commonly called medallions, of Caracalla. In the Thracian Chersonese the most important series is one of autonomous silver coins, probably of the town of Cherronesus. The money of the island of Thasos is of much interest. It commences with extremely old silver coins, which appear to be on the Æginetan system. These are followed by a series on the Attic weight, ranging from a very early time to the commencement of the period of good art, some of the latest being of fine style. The obverse-type represents a satyr carrying a female, and the reverse-type is an incuse square, divided, more or less rudely, into four parts. After this we observe coins bearing for their obverse-type the head of Bacchus. Some of these are of the best period of art, and one, a tetradrachm, is among the very finest Greek coins. The head of Bacchus is treated in a sculptural style that is remarkably broad and grand. The massive, powerful features, and the formal hair nearly falling to the neck in regular curls, like those of the full beard, are relieved by a broad wreath of ivy leaves designed with great delicacy and simplicity. The reverse bears a Hercules kneeling on one knee and discharging his bow, a subject powerfully treated. Of a far later period there are large tetradrachms much resembling those of Maronea. They were probably struck, in both places, in the early days of the Roman rule. The money of Lysimachus is of far higher importance than that of any other king of Thrace. The most common pieces are, in gold, staters, and in silver, tetradrachms. The earlier coinage follows the types of that of Alexander the Great. The later coinage, of which the examples are far more numerous, bears as the obverse-type what is considered to be the first Greek regal portrait, the head of Alexander with goat's horns, deified as a young Jupiter Ammon:[5] the reverse-type is a seated Minerva holding a little Victory. There are coins of the kings of Pæonia, which are chiefly silver, and have a resemblance to those of the Macedonian sovereigns, although they are somewhat barbarous.

Greek Coins. Thrace.

Macedon.

The coinage of Macedonia, both civic and regal, is of great variety and interest. It commences at an early time, probably towards the end of the sixth century B.C. The oldest pieces are of silver, copper, and not long afterwards gold, having come into use

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[1] *Æn.* i. 441-445.

[2] *Pun.* ii. 410, 411.

[3] Οἱ δὲ καὶ τοῦτο περὶ Καρχηδόνος φασὶν, ὡς ἄρα οἱ περὶ τὴν Ἔλισσαν, ἦγουν οἱ μετὰ τῆς Διδοῦς, ὀρύσσοντες εἰς τόλεως κτίσιν, καὶ βοὸς ἱερόντες κεφαλὴν, ἀπίσχοντο τοῦ ὀρύσσειν, οἷα ὀπτευσάμενοι μόχθους καὶ δουλείαν συνεχῆ, ὅ καὶ οἱ βόες πάσχουσιν· ὀρύξαντες δὲ περί που φοίνικα πεφυτευμένον, εὗρον κεφαλὴν ἵππου, καὶ συμβαλόντες σημαίνεσθαι σχολὴν ἀυτοῖς, καὶ παρ' ἄλλων δόσιν τροφῆς, καθὰ καὶ τοῖς ἵπποις, ἵκτισαν ἐν τῷ τοιούτῳ τόπῳ τὴν Καρχηδόνα, κ.τ.λ. (Eustathius ad Dionysium, *Perieg.* 195; comp. *Justin.* xviii., cap. v.)

[4] *Sicilia Populorum et Urbium Regum quoque et Tyrannorum Veteris Nummi Saracenorum Epocham antecedentes*, fol., Panormi, 1781 (with two appendices—first, 1789; second, 1791).

[5] Some have doubted this type to represent Alexander, but the evidence in favour of its doing so must be considered to be conclusive.

Greek Coins. Macedon.

for coinage during the fourth century B.C. The types are of a Greek character, with, in the earliest class, a tendency to barbarism. Their art, although at first slow in its development, attained great excellence. The standard of the earlier coins is that of the old Macedonian talent, which is better known as the Alexandrian or Ptolemaic, from its restoration to use in the coinage of Egypt by the first Ptolemy. The weight of its drachm was at first about 58 grains. The heaviest denomination in Macedonia was an octodrachm. The coins of this denomination are of an early period, all dating about the time of Alexander I., and indicate the metallic wealth of the country rather than the success of its trade at that time, since they are more likely to have been coined from the produce of the mines than from silver acquired in commerce. Philip II. adopted for gold money, which he was the first Macedonian king to issue, the Attic weight, striking staters on that system, while he maintained the old standard for his silver coinage. Alexander the Great made the weight of the gold and silver money the same by using the Attic system for both; and from his time no coins of kings of Macedon, in these metals, were struck on any other.

The series of Macedon commences with coins of the kingdom or province bearing the name of the Macedonians. Some of these seem to have been issued under the kings, but others are of the Roman domination. The money of Acanthus comprises fine archaic tetradrachms, and others of the commencement of the period of good art. The type of their obverse is a lion seizing a bull. There are smaller pieces of various kindred types. The money of Æneia is chiefly interesting from its bearing the head of the hero Æneas. The town of Amphipolis is represented by a long series. There are tetradrachms having on the obverse a head of Apollo facing, which are of fine work, but not in the severe and best style. The reverse-type is a torch in an incuse square. Other silver, as well as copper coins, display good art. There are also many Greek imperial copper pieces of this place. The territory of Chalcidice is pre-eminent for the high excellence of some of its silver coins. These are tetradrachms of the best period, and of an admirable style. The more important design is that of the obverse, representing a head of Apollo in profile, crowned with laurel. It is in very high relief, and treated with great simplicity, though not with the severity of somewhat earlier pieces. The delicacy of the features is balanced by the shortness of the hair, and the broad, heavy wreath of laurel. On the reverse is a lyre of seven strings. Other tetradrachms are of comparatively coarse work. There is an early series of coins of Lete. Some are of a remote date, and none later than about the time of Alexander I. The obverse-type is a Pan or faun with a nymph, and on the reverse is an incuse square. These coins are nearly all tetradrachms. Of Neapolis there are archaic silver and copper coins, with, on the one side, a Gorgon-head, and on the other a head of a female. The coins of Philippi are in the three metals. The gold pieces are fine staters, with the head of Hercules in the lion's skin on the obverse, and on the reverse a tripod. The silver and early copper pieces have the same types. The style of all points to the reign of Philip II., who, having discovered or gained possession of a rich gold mine near Crenides, changed its name to Philippi. Pydna is represented by copper money of the best period, sometimes fine, and, in the case of one specimen we have seen, very beautiful. There is a long series of Greek imperial coins of Thessalonica. Trælium must also be mentioned on account of its archaic silver coinage, and for the excellence of some of its copper money of the best time. The class of uncertain coins of Macedonia is deserving of careful study. It comprises very early silver pieces, among which octodrachms of the Macedonian talent should be especially noticed. One of the latter, and a smaller piece, bear inscriptions which have caused them to be attributed to the Orestæ, but both Millingen and Colonel Leake assign them to a people of Thrace, not otherwise known to us, whom they call the Orescii, from the inscriptions of the coins. There are also two coins of Geta, King of the Edoni, a prince of whom we have no other record. They are octodrachms of about the period of Alexander I. On the obverse is represented a hero wearing a causia driving two bulls, and the reverse bears an incuse square of four divisions, having around it on one coin ΓΕΤ[Α]Σ ΒΑΣΙΛΕΩΣ ΗΑΩΝΑΝ, and on the other ΓΕΤΑΣ ΗΑΟΝΕΟΝ ΒΑΣ[Γ]ΑΕΥΣ. The difference, not alone in construction, but in orthography, and the use of long and short vowels, is very remarkable, and seems to indicate barbarism, since the coins are unquestionably of the same period. Both were found in Babylonia by Mr Rich,—a circumstance that finds its explanation either in the commercial importance of the Macedonian silver at this time, or in the probability that the remains of the armies of Darius and Xerxes carried away with them some Greek money taken as plunder.

Greek Coins. Macedon.

The coinage of the Macedonian kings, since it includes the money of Philip II. and that of Alexander the Great, is equal in interest to any other Greek regal series. The oldest pieces are of Alexander I., the contemporary of Xerxes. These are octodrachms, resembling those of Geta, King of the Edoni, but having on the obverse a hero by the side of a horse; and coins of a lower denomination with the same type. The next king known by his coinage is Archelaus (B.C. 413–399), of whose reign we have silver coins, some of which are of archaic, and others of fine work, as well as the earliest copper money of the series. Of Amyntas II. (B.C. 397–371) there are coins of fine work, both in silver and copper. The money of subsequent reigns is not remarkable until that of Philip II. His gold pieces are staters and a small division. The abundance of the former is attributable to his having possessed the gold mine of Philippi. The staters are Attic didrachms, and are of fine, but not of the highest art. They bear on the obverse the head of young Hercules,—not of a sufficiently manly cast, and resembling that of Apollo, though rightly attributed to the former divinity by Mr Burgon. On the reverse is a goddess in a victorious Olympic biga, a type we have already explained: in one case Victory flies before the horses. These coins were afterwards known as Φιλιππεια, and the gold money of Alexander as Αλεξανδρεια—appellations which probably did not include larger or smaller pieces. Horace calls the gold coins of Philip, "Philips" ("regale nomisma, Philippos"). (*Epist.* ii. 1., v. 232.) The silver coinage of Philip is exclusively composed of tetradrachms of the Macedonian talent. Their type of obverse is a head of Jupiter; and of reverse either a mounted hero wearing a causia, or a victor in the horse-race with a palm, a design already discussed. There is a difficulty in deciding as to the copper money of Philip.

The coinage of Alexander the Great, both in the number of the cities where it was issued, and in its abundance, excels all other Greek regal money; but its art is, without being despicable, far below excellence. The types are not remarkable in themselves, and there is a great sameness characterizing the entire series. The system of both gold and silver is Attic, Alexander having made the money of these metals uniform in weight by substituting the Attic for the Macedonian silver talent. The gold coins are distaters or gold tetradrachms, hemistaters or drachms, with their half, and a smaller denomination. The types of the distaters and staters—the latter of which were the most common pieces—are, for the obverse the head of Minerva, and for the reverse Victory bearing a standard. The largest silver piece is the decadrachm, of which there is but a single specimen known, now in the British Museum. The types of the tetradrachms and most of the lower coins are, on the obverse the head of young Hercules in the lion's skin, and on the reverse Jupiter seated, bearing on his hand an eagle. The head has been supposed to be that of Alexander; but this is not the case, although there is probably some assimilation to his portrait. The great currency was of tetradrachms, which were struck in different cities, distinguished by proper symbols and monograms. The classification of these coins is difficult, and has not been sufficiently studied. The copper money is not remarkable. (There is an essay upon Alexander's coinage by M. Müller of Copenhagen, which will be found of service in its examination.[1])

The coinage of Alexander is followed by that of Philip Arrhidæus, in gold and silver. To Alexander Ægus no money has been assigned with certainty; but it is probable that coins in silver and copper, usually attributed to Alexander II. of Epirus, were issued by Ptolemy I. in Egypt in the name of this titular sovereign. The obverse-type of these is a head of Alexander the Great, like that on the coins of Lysimachus, in the silver pieces covered with the skin of an elephant, and in the copper ones bare. The money of Cassander and his sons Philip IV. and Alexander IV. is not remarkable. The coins of Antigonus, King of Asia, are placed in the Macedonian regal series, since he was a successor of Alexander, and his son Demetrius gained the Macedonian sovereignty; but this is scarcely a correct classification. He struck very fine tetradrachms, having on the obverse a head of Neptune, and on the reverse Apollo seated on the prow of a galley,—types indicating the naval power of this king. The coins of Demetrius I., Poliorcetes, comprise fine tetradrachms, the types of which have a similar reference. They bear either, on the obverse his portrait horned, and on the reverse a figure of Neptune, or on the one side a winged female figure (Victory)[2] in the prow of a galley, blowing a trumpet, and on the other Neptune striking with his trident. The latter types cannot be doubted to relate to the great naval victory which Demetrius gained over Ptolemy. The tetradrachms of Antigonus I., Gonatas, which are of inferior style and work to those of Demetrius, have types which appear to refer in like manner to the great event of his time. Their obverse-

[1] *Numismatique d'Alexandre le Grand*, suivie d'un Appendice contenant les Monnaies de Philippe II. et III. Par L. Müller, 8vo, Copenhagne, 1855 (with a vol. of plates in 4to).

[2] Eckhel supposes this figure to be Fame, but in this instance he seems to have judged hastily (*Doct. Num. Vet.*, vol. ii., pp. 120, 121).

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type is a Macedonian buckler, with the head of Pan in the midst; and their reverse-type Pallas Promachus. The head of Pan is supposed to have been taken as a device in consequence of the panic which led to the discomfiture of the Gauls at Delphi,—panics being attributed, as the name imports, to the influence of Pan. The money of Demetrius II. and Antigonus II. is unimportant. The tetradrachms of Philip V. have, on the obverse two kindred types, in each case a head in the helmet of Perseus, but one apparently representing Philip in the character of that hero, and the other the hero himself, though probably assimilated to the king. The reverse bears a club. Other tetradrachms and smaller coins have a simple portrait of Philip. The tetradrachms of Perseus are of a fair style, considering the time at which they were struck. They bear on the one side the king's head, and on the other an eagle on a thunderbolt.

Thessaly.

The coinage of Thessaly presents very few specimens of a remote period, while coins of the best time are numerous. The latter are in general remarkably like the finest coins of Sicily and Italy, although there are some of a severer style. The weight is generally, if not always, adjusted to the Æginetan talent. Of the town of Gomphi or Philippopolis there is a beautiful drachm, having on the obverse a female head facing, which is probably that of Juno. The coins of Lamia are also to be noticed for their beauty. The series of Larissa is well worthy of a careful examination. It commences with archaic pieces, and some of the early period of good art, but of rather coarse execution. These are followed by coins of fine work. The usual obverse-type is the head of the nymph of the fountain facing, and on the reverse is generally a horse, either free or drinking. On some the head is treated in a very rich manner, like that of the fountain-nymph Arethusa, facing, on tetradrachms of Syracuse; indeed, in one case, the resemblance, in its obverse, of a didrachm of this place to these Sicilian coins is most remarkable. The small silver pieces have very interesting types, relating to the nymph of the fountain, and to be compared for mutual illustration with the common didrachms of Terina and with some of those of Elis. The copper money is also fine. The coins of Pharsalus and Pheræ are worthy of note. Of the tyrants of the latter town, Alexander and Tisiphon are represented by their coins; but we agree with Mr Burgon in thinking the tetradrachms which have been ascribed to the former to be of a king of Pæonia. The coins of Tricca resemble those of Larissa.

Illyricum.

The coinage of Illyricum is poor and rude. The weight is at first Æginetan, but afterwards it appears to have been generally Attic, a change probably attributable to Corinthian commercial influence. Of Apollonia there is a large series of Attic drachms, the most important type of which is a reverse one representing three nymphs dancing around what appears to be a burning hillock, but may be intended for a volcano. There are also a few Greek imperial pieces. Dyrrhachium, which never, as far as is known, bears on its coins the more famous name of Epidamnus, is represented by an important series. First, there are Æginetan didrachms, with Cocyræan types,—on the obverse a cow suckling a calf, and on the reverse a device supposed to be a kind of ground-plan of the famous gardens of Alcinoüs. These are succeeded by didrachms with Corinthian types, and, of course, on the Attic standard; and then the old types are resumed, but apparently without a return to the former weight. Dyrrhachium, it should be remembered, was founded partly by Corcyræan and partly by Corinthian colonists. The Corinthian types are, however, to be at least mainly ascribed to subsequent influence, although their adoption may have been furthered by the recollection of the origin of the town. A didrachm of the first class bears the name of a King Monunius, who has been supposed to be the Illyrian prince Monunius mentioned by Livy and Athenæus, and who reigned about B.C. 180. All the Æginetan didrachms, however, must be concluded to have been struck from about B.C. 400 to 300, the Attic money supplanting them at near the latter date; and therefore this supposition is not tenable.

Epirus.

The coins of Epirus are of higher interest and beauty than those of Illyricum. The weight is generally Æginetan, except in the regal series, which follows the Attic standard. Of the Epirots there are silver coins which appear to be Æginetan didrachms and drachms of low weight. They are of about the time of Pyrrhus and of a later period. The city of Ambracia is represented by beautiful silver pieces, with, on the one side a veiled female head, and on the other a kind of obelisk. Of Damastium there are rude coins, which are doubtless of an early period. The long series of Greek imperial money of Nicopolis must also be mentioned.

Greek Coins. Epirus.

The coinage known to us of the kings of Epirus begins under Alexander I. His coins have been found in the three metals, but they are rare. It is probable that they were struck in Italy while he was in that country. The coins of Pyrrhus are of high interest, and remarkable for their beauty, although in a greatly decorated style. There can be little doubt that they were for the most part struck in Italy and Sicily—at Tarentum, Syracuse, and probably other towns also. Some of the gold pieces are fine, but the silver are more worthy of note. The tetradrachm has for the type of the obverse a head of the Dodonæan Jupiter crowned with oak, and for that of the reverse Juno seated. A fine didrachm bears on the obverse a young male head helmeted, which we believe to represent Pyrrhus, though in a peculiar manner. It is said that Pyrrhus was judged by his contemporaries to bear a great resemblance to Alexander in face and manner;[1] and if we compare this head with that king's on the coins of Lysimachus, we perceive a remarkable similarity. There is what we should call a strong family likeness, if the term be admissible, between the two. The features are not alone similar, but they have the same animated expression. Visconti considered the head in question to be that of Pyrrhus, and brought forward the argument given above, but he did not meet the objection that the treatment is ideal. This difficulty is overcome if we consider it to have been an idealized portrait of Alexander assimilated to that of Pyrrhus, as the head of Hercules on the money of the former king is probably assimilated to his own. The portrait of Alexander on the coins of Lysimachus, and again on those which we suppose to be of Alexander Ægus, is also ideally treated, more especially in the latter case.[2] Among the copper coins of Pyrrhus we must remark the beautiful ones with the portrait of his mother Phthia. The money ascribed to later kings of Epirus is of doubtful attribution.

Corcyra.

The coinage of the island of Corcyra generally, or of the Corcyræans, commences with very early didrachms and drachms of the Æginetan weight. These are followed by coins of the early part of the period of good art, but usually somewhat rudely executed. The types of the didrachms of this and the preceding group are, on the obverse a cow suckling a calf, and on the reverse the supposed gardens of Alcinoüs, both, as we have seen, like those of the first didrachms of Dyrrhachiums. These are followed by coins with, on the one side, the head of an androgynous Bacchus, and on the other a Pegasus. The former of these types is illustrated by the fame of the wine of Corcyra in ancient times; the latter by the colonization of the island from Corinth, to which town this type must be held to refer. These and the later coins are probably on the Attic standard. Copper money is abundant, both of the autonomous and the imperial class. There are, however, no pieces which can be considered to be of very fine art in either silver or copper.

Acarnania.

The coins of Acarnania are not remarkable for beauty, or for variety in their types. We must mention those of the Acarnanians, which are Æginetan didrachms and drachms, having on the obverse the head of the Acheloüs, beardless, and covered with a bull's skin, and on the reverse a seated Apollo. These are probably of about the time of Alexander the Great. Of Leucas there are silver and copper coins, the latter being numerous; and of Œniadæ, copper, with, on the one side the head of Jupiter, and on the other that of the Acheloüs, bearded, and in a bull's skin. The honour in which the Acheloüs was held explains the occurrence of its head in more than one series.

Ætolia.

In Ætolia, the money of the Ætolians must be mentioned. The gold and silver coins are fine, but not of the best period or of a very good style, and are probably to be referred to about Alexander's time. The gold pieces have on the obverse the head of Minerva or that of Hercules in the lion's skin, and on the reverse Ætolia, personified as a female seated on shields, with a little Victory on one hand. There are similar types on the silver coins; and the drachms bear others relating to the chase of the Calydonian boar. The latter have on the one side the head of Atalanta wearing a causia, and on the other the boar and the spear-head with which he was killed. The standard is first Æginetan, and then Attic.

Locris.

In Locris the coins of the Locri Opuntii, no doubt struck at Opus, claim our notice. There are didrachms and hemidrachms on the Æginetan weight, of the best period, and of a style which is admirable, notwithstanding that it is very rich in the treatment of the subject occupying their obverse. This is a head of Proserpine, with corn-leaves in her hair. The reverse bears a warrior in a fighting attitude, with sword and shield. His name, AIAΣ, which is sometimes written beneath, shows that he is the Lesser Ajax, who led the Locrians to the siege of Troy.

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[1] Καὶ γὰρ ὄψιν ἔσχε καὶ τάχος ἐοικέναι καὶ κίνημα τοῖς Ἀλεξάνδρου καὶ τῆς φορᾶς ἐκείνου καὶ βίας παρὰ τοὺς ἀγῶνας ἐν τούτῳ σκιάς τινας ὁρᾶσθαι καὶ μιμήματα, τῶν μὲν ἄλλων βασιλέων ἐν πορφύσεις καὶ δορυφόρους καὶ κλίσει τραχήλου καὶ τῷ μεῖζον διαλέγεσθαι, μόνου δὲ Πύρρου τοῖς ὅπλοις καὶ ταῖς χερσὶν ἐπιδεικνυμένου τὸν Ἀλέξανδρον. (Plut. *Pyrr.*, cap. viii.)

[2] Millingen (*Considérations*, Supp., pp. 27, 28) supposed the head on the didrachm of Pyrrhus to be intended for that of Achilles, and his opinion has some support from the occurrence of the letter A in the field. This letter would, however, be equally appropriate in the case of Alexander.

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There are silver coins of the Phocians and of Delphi. Those of the former are of archaic and of fine art, and follow the Æginetan system. The coins of Delphi, which are on the same standard, are not an important series. Among them are Greek imperial pieces, some of which have a representation of the famous temple on the reverse.

Bœotia.

The coinage of Bœotia forms an interesting series. It is chiefly of a period anterior to the reign of Alexander, under whom the political importance of Thebes and the whole country came to an end. The silver money is fine in its art, and a great similarity is observable in its fabric and types. The standard is Æginetan, but the Attic must have been introduced after Alexander's time, as there are some specimens of its weight. The copper money is poor. Of the Bœotians there is a long series. The great currency was of Æginetan didrachms, but many smaller coins are found. In the archaic pieces the obverse-type is a Bœotian buckler, which is probably that of Hercules, and the reverse bears an incuse square. On coins of the early part of the time of good art we find the buckler and a diota; the former seeming to stand for Hercules, and the latter for Bacchus, corresponding to the types of Thebes with the head of Bacchus on one side and Hercules on the other. Later coins of these types, and of a very fine style, bear on the reverse the earlier letters of proper names, which can only be of magistrates. One, a didrachm, may be particularized for its beauty and on account of the inscription ΕΠΑΜΙ, which Mr Burgon supposes to be part of the name of the illustrious Epaminondas, an opinion which the style of the coin corroborates. On this piece there is a rose above the diota. The other names require to be carefully studied. There are still later pieces of inferior work. Very rare tetradrachms of Attic weight, standing quite by themselves in the coinage of Bœotia, must be referred to a time subsequent to that of the silver coins of Æginetan weight. Their obverse-type is a head of Jupiter, and their reverse-type a seated Neptune.

The coinage of Orchomenus is fine. Very beautiful hemidrachms of the best time, with the head of Proserpine on the obverse, must be particularized. Of Tanagra there are coins of the archaic and the good period. The money of these lesser towns cannot, however, be compared for importance to that of Thebes. A few small gold coins have been found of this city; but the great currency was of silver, and chiefly in didrachms, of course on the Æginetan standard. The earliest silver pieces must be assigned to a time not long after the beginning of Greek coinage. These have on the obverse the usual buckler, and on the reverse an archaic Θ in the midst of an incuse pattern. After these there are pieces of early good style and others of rich work of a later time, although also of the age of the best art. The types appear mainly to relate to Hercules and Bacchus. We may notice didrachms, with on the obverse the buckler, and on the reverse the diota, with the buckler, and the infant Hercules strangling serpents, and with the head of Bacchus, and Hercules stringing his bow. The last reverse-type is a very fine example of the early work of the good time. The copper money is not remarkable. The only other Bœotian town which need be mentioned is Thespiæ, of which there are silver coins of a late archaic time.

Attica.

In Attica the great series of Athens demands our consideration. The gold money is not common, and of a late time, probably near that of Philip. The pieces are staters or didrachms. The silver is very plentiful, and must anciently have had a high commercial importance. We have already spoken of the denominations in treating of those of Greek coins generally. It may be here mentioned that the decadrachm of Athens is extremely rare; that the most common coin is the tetradrachm; and that some of the smaller pieces are of frequent occurrence. The earlier coins have archaic types, commencing about B.C. 500, and reaching down, without any essential change of style, through the period of good art,—a circumstance which can only be attributed, as already remarked, to a desire not to injure the credit of the Athenian money for purity among the nations which received it in trade. They are thick and of coarse fabric. There was no doubt a still older Athenian coinage, of which specimens must remain; but on this subject nothing satisfactory has as yet been published. The most notable coins of the earlier class are the decadrachm, which has on the obverse the head of Minerva, and on the reverse an owl with spread wings, with the inscription ΑΘΕ, and an olive branch, and the tetradrachm, with the same obverse, and on the reverse an owl, usually turned to the right, but sometimes to the left, and more rarely facing, but with its wings closed. The coins of the later class are thinner, and consequently broader, and of a more recent style, than those of the earlier. They probably commenced not long after the time of Alexander, and lasted until that of Sylla, if not later. The principal pieces are tetradrachms, each bearing the names of three magistrates, among which occur those of two kings, Antiochus (doubtless the third of that name), and the famous Mithradates of Pontus. Their obverse-type is a head of Minerva, probably copied from that of the ivory-and-gold statue by Phidias in the Parthenon, rather than that of the bronze one by the same artist on the Acropolis; and their reverse-type is an owl upon an amphora. The Athenian copper is of low art. The first attempt to introduce it failed;[1] but the principal piece (χαλκοῦς) was common in the time of the poet Philemon,[2] about B.C. 300. The most remarkable copper coins are two bearing representations of the Acropolis and the great edifices. Both have on the obverse a head of Minerva. The reverse of one represents the Acropolis, with the grotto of Pan, the statue of Pallas Promachus, the Parthenon, and the Propylæa, with the steps leading up to the latter. The reverse of the other shows the theatre of Bacchus, above which are caverns in the rock, and higher still the Parthenon and the Propylæa.[3] Respecting the rest of Attica we need only remark that there are fine copper coins of Eleusis, and that there are Greek imperial pieces of Megara.

Greek Coins.

Ægina.

The money of the island of Ægina is of especial interest, since with it Greek coinage is said to have originated. The story is, that at a time when Ægina was a dependency of Argos, Phidon, king of Argos, struck the first Greek money there, in the eighth century B.C. It is said that previously silver was formed into spikes (ὀβελίσκοι), of which six made a handful (δραχμή); and that thus the name of the drachm and its sixth, the obolus, originated; but this account may be an invention of later times. There can be no doubt, however, that the earliest Æginetan coins are of extreme antiquity. The weight is of course on the talent of Ægina. The oldest pieces are very primitive didrachms, bearing on the obverse a tortoise, and on the reverse a rude incuse stamp. Afterwards the stamp becomes less rude, and later has a peculiar shape. There are some coins of the early part of the fine period, and of excellent work. The great currency was of didrachms. The copper coins are not remarkable, but some appear to be of a time anterior to most Greek pieces in this metal.

Achaia.

The series of Achaia is numerous and interesting. First we must mention the coins of the Achæan League. The principal pieces appear to be tetrobola, since their weight is about that of two-thirds of a light Attic drachm. The type of the obverse is a head of Jupiter, and that of the reverse ΑΧ, for ΑΧΑΙΩΝ, in a monogram, with the name of the people by which the coin was issued, either in full, or represented by its commencement, commonly the latter, and generally some distinctive symbol. There is also copper money of this confederacy. Corinth is represented by a very large series of coins, the weight of which is always Attic. The chief coin was the didrachm. The oldest pieces are of a very early time, and bear on the obverse a Pegasus, and on the reverse an incuse pattern. On coins of a subsequent time, of archaic style, latterly approaching to that of the good period, we find the Pegasus still on the obverse, but on the reverse the head of Minerva in an incuse square. Of the period of the excellence and decline of art there are numerous specimens, some of which are of beautiful work, although generally devoid of the severity of the highest Greek art. The didrachms have on the one side a Pegasus, either galloping, which is most common, or standing, or drinking; and on the other the head of Minerva, sometimes with a laurel-wreath on the helmet, which, it may be noticed, is always Corinthian. The old letter koppa, the initial of Corinth according to the archaic orthography, is generally seen on the obverse, as well as various symbols and letters, on the reverse. The smaller coins have the same obverse, but generally on the reverse a head of Venus, sometimes in a cap. Some of these, which appear to be principally tetrobola, are of good work; and there are a few of fine early style. There are some drachms with Bellerophon in a combatant attitude, mounted on Pegasus, on the one side, and the Chimæra on the other. The autonomous copper money is poor, but often of fair work, and interesting, especially when the type relates to the myth of Bellerophon. Under the Romans this city was made a colonia; and we have a large and interesting series of the copper coins struck by it as such. To the colonies of Corinth is assigned a large series of silver coins, chiefly, at least, didrachms,—for it is doubtful if there are smaller pieces,—with the common types of the parent city. These coins probably do not, in some cases, indicate anything more than Corinthian origin,—and there can be no doubt that the didrachms of Corinth had such a reputation in commerce that other cities would have been ready, when it was possible, to issue similar pieces,—but in other cases they are witnesses of a contemporary influence or actual supremacy of that great mart.

There are copper pieces of Patræ as a Roman colonia, and silver and copper coins of Phlius, both of the period of good art. The ancient city of Sicyon is remarkable for the great beauty of its

[1] Aristoph. *Ran.* 737; *Eccles.* 810. [2] Ap. Meineke, *Com. Frag.* vol. iv. p. 24. [3] See *Numismata Hellenica*, "European Greece," 21, *et seq.*

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money. Notwithstanding its reputation for antiquity, no coins of the archaic time have been attributed to it. The silver coins commence in the time of early good art, and continue until a late period, perhaps not far from that of the Achæan League. The standard, at least during the good time, is Æginetan. The most beautiful specimen known to us is a drachm of an excellent and simple style, having on the obverse a dove, as if alighting, and on the reverse the letter Σ, placed horizontally like M, with an ornament beneath it. There are didrachms of a somewhat later time, which, although very fine, are a little too decorated, or at least not severe, in their style. The type of their obverse is the Chimæra, and that of their reverse a flying dove within a wreath. The copper is mainly of good time, but some pieces may be late.

Elis.

The money of Elis, or the Eleans, forms a most interesting series, many of the silver coins being of the highest style, and almost all bearing interesting devices, remarkably executed. The weight is Æginetan; and didrachms must have been the most important coins. The inscription, in full ΓΑΛΕΙΩΝ, is remarkable for the use of the digamma. The earliest coins are thick pieces of archaic work, and singular style, probably struck about the time of the expedition of Xerxes. The obverse bears a flying eagle carrying a serpent, and the reverse, a thunderbolt, sometimes of an elaborate form. Later archaic coins have the eagle carrying a hare or serpent, and a winged female figure. Next in order of time are the first fine coins. Some of these have on the obverse an eagle preying on a hare, and on the reverse a winged female figure seated on a base. This reverse is very beautiful in one example we have examined. Still later than these are coins of the finest style. On the obverse is a head of Juno, in a tiara, with honeysuckle ornaments, and sometimes bearing her name ΗΡΑ; and on the reverse an eagle, or a thunderbolt, within a wreath. The head of Juno is an admirable design, and fully proves that the Greeks attained as great success in coin-engraving as in sculpture. Not only is the face most beautiful, but it is perfectly appropriate to the character of Juno as drawn by the poets, and fit for the form and surface of a coin. There are also pieces in a later style. The copper money is not remarkable.

Cephallenia, &c.

We have next to notice the coinage of the island of Cephallenia. The very early and archaic silver coins of Cranii must not be passed by, nor the money of Pale and Same, all cities of this island. Of the island of Zacynthus there are silver coins, usually of rather coarse work. Didrachms of the early good style, on the Æginetan standard, must be mentioned. The coins of Ithaca are of copper. They are of interest on account of their common obverse-type, which is a head of Ulysses.

Messenia.

Returning to the mainland, we first notice the money of Messenia, or the Messenians. The most remarkable coin is an Æginetan didrachm of the finest style, having on the obverse a head of Proserpine, excelling in design the similar subjects on the money of Syracuse. On the reverse is a figure of Jupiter. The other silver coins are of a comparatively late time, many being of about the period of the Achæan League. The copper money is plentiful, but not interesting. In Laconia it is only necessary to mention the coinage of Lacedæmon. As we might have expected, there are no early coins, the silver money being, like so much of that of the Greek cities, of about the time of the Achæan League. Among the types of the autonomous copper pieces may be noticed the head of the Spartan lawgiver, with the inscription ΑΥΚΟΥΡΓΟΣ.

Argolis.

The series of Argos in Argolis commences, as one would have anticipated, with coins of a very early period. The standard is Æginetan. The first coins are the drachm, with a wolf on the obverse, and on the reverse A, the initial letter of the name of the people and city, in an incuse square of two divisions, and the hemidrachm and a smaller piece, each with a wolf's head on the obverse, and the same type of reverse as the drachm. The most common silver coins have as their obverse-type the fore-part of a wolf; and the head also occurs on smaller pieces. Among coins of the period of good art we must especially notice those which have for the obverse-type the head of Juno wearing a tiara; a design which, although sometimes of great beauty, is not equal to that of the coins of Elis, the style being less simple. A reverse-type of one of these coins, a drachm, represents Diomed stealthily advancing with the Palladium in his left hand, and a short sword in his right. On coins of the period to which this belongs (for it is certainly anterior to Alexander), the devices were of a strictly religious character. We cannot suppose a historical subject to be introduced; and it is therefore evident that the Trojan war was then considered by the Argives to be mythical. It may be remarked that some of the copper coins of Argos are of good style. Of the town of Trœzen there are very fine silver coins of the early part of the best period of art, and some of a later time.

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Arcadia.

The money of Arcadia is interesting, although it does not form a large series. Some pieces are doubtless among the most ancient struck by the Greeks, and the types of these and later coins are often connected with the remarkable myths of this primæval part of Hellas, showing particularly the remains of its old nature-worship. The first series to be noticed is that of Arcadia generally, or the Arcadians. It commences with very ancient silver coins, probably of at least the sixth century B.C., bearing types which continue to the early part of the fine period. These coins are chiefly hemidrachms on the Æginetan system, of which the usual types are, for the obverse, Jupiter Ætophorus seated, the eagle usually represented as if flying from his hand; and for the reverse, a female head. Of a later time, from about the age of Alexander, there are coins with, on the obverse, the head of Jupiter, and on the reverse Pan seated. These form part of the general currency which followed that of Alexander, and was most prevalent under the Achæan League. As they have everywhere a maximum weight of about 40 grains, it is probable that they were equal to low Æginetan hemidrachms, as well as to Attic tetrobola similarly debased; and from their generally having come into use where the system of the former had obtained, they were probably considered as related to it, although actually Attic tetrobola. In Crete, however, the Æginetan standard was supplanted by the Attic, and the same must have been the case in Bœotia, although there no pieces of the later issue above the weight of Attic tetrobola seem to have been common. The coins of Heræa are interesting. They commence at a very remote period, and last to the time of good art. The types of the oldest are, for the obverse, a female head veiled, probably that of Juno, in an extremely archaic style; and for the reverse, the retrograde inscription ΑΡΞΙ, between two horizontal ornamented borders. These and the other archaic coins are hemidrachms, and a smaller piece, on the Æginetan standard. The antiquity of Mantinea is, in like manner, attested by its money. The silver coins of a very early time have on the obverse a bear, representing Callisto, the mother of Arcas, and on the reverse three acorns in a triangular incuse depression. Others, of a later time, have on the one side an acorn, and on the other the letter M. As to the type of the bear, it may be observed that Callisto was particularly honoured here;[1] and as to that of the acorn, that its occurrence shows that the prominence given to this fruit in the myths relating to Arcadia must be due to a primæval nature-worship, and not to its having been supposed to have been the food of the earliest inhabitants. The silver coins of Megalopolis are important, since we know the city to have been founded B.C. 370. The types are the same as those of the coins of the Arcadians of the same period, the obverse bearing the head of Jupiter, and the reverse Pan seated.[2] The silver coins of Pheneus must be noticed to be of fine work. The last Arcadian town of the money of which we shall speak is Stymphalus. The finest coin attributed to this place is a magnificent didrachm on the Æginetan standard. The obverse bears the head of Diana laureate, and the reverse Hercules striking with his club. This coin, although of great beauty, is not of the highest style. The head is not sufficiently simple in its treatment, being too rich in the details. The other design also errs in a want of meaning. When Hercules is represented shooting, there is no need to portray the object which he attacks; but when he uses his club, there is a defect if we do not see what he is about to strike. Mr Burgon thinks this piece must be of a city of the same name in Crete, as yet unknown to us from any other source. Not alone is the style of the coin remarkably Cretan, and even the mechanical execution, but the very same types occur on Æginetan didrachms of Chersonesus of Crete. Yet Diana and Hercules were both worshipped in the Arcadian city. The smaller silver coins are undoubtedly of that place. They have on the one side the head of Hercules, and on the other, the head and neck of a Stymphalian bird, most resembling those of a vulture. There were representations of these birds in the temple of Diana at Stymphalus.[3] The series of Tegea can scarcely be considered as important, but three of the reverse-types of its copper coins are very interesting. Two of these relate to the story that Minerva gave a jar containing the hair of Medusa to her priestess Sterope, daughter of Cepheus, in order that she might terrify the Argives should they attack Tegea during the absence of Cepheus, when Hercules desired his aid in an expedition against Sparta. The third represents a hind suckling the infant Telephus.

Crete.

The coins of Crete bear witness to its ancient wealth. Silver must have been abundant, whence, except it were anciently found

[1] Paus. *Arc.* 3, 9, 35, 36.

[2] Colonel Leake (*Num. Hel.*, Eur. Gr., p. 72) supposes that the later silver coins of Arcadia were struck at Megalopolis; and this would explain the identity of their types with those of the coins of this place.

[3] Paus. *Arc.* 22.

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in the island (and modern researches there have not yet detected any traces of this metal, much less of its former working), we must suppose an extensive and active commerce. The period over which the autonomous silver coins range extends from about the latter part of the sixth century B.C. to the beginning of the Roman rule. The autonomous copper coinage belongs only to the latter part of this period, and gold money has not been found. The imperial coins are not numerous. The types have a very local character, which connects them with early Greek mythology. Neptune, Jupiter, Juno, Hercules, and the local goddess Britomartis, identified with Artemis, are among the principal divinities. Subjects connected with the myths of Europa and that of the Minotaur also occur. Many series have evident reference to the primæval nature-worship. The art of the silver coins of Crete is well deserving of study. In general it is at first rude, and suddenly attains excellence. In its perfection it stands by itself, as wholly distinct from that of any other class of Greek money. In essential excellence it is inferior to no other style, but it errs in a want of fitness, necessarily arising from its intensely pictorial character. The perception of beauty which it displays is very great, although in female heads there is too much richness. The figures, the animal forms, and the trees are drawn with the most admirable truth and freedom, and, notwithstanding, often in very low relief for Greek coins. The pictorial character of this art is shown not alone in the choice of subjects, but in the extremely natural mode in which they are treated, with a constant preference for perspective, without in either case a regard for the form or surface of the coin. Thus, as examples of Greek art, the finest Cretan pieces are of the highest value; but as examples of that art as applied to coins, they are to be consulted with great caution. The standard of the older silver coins, comprising all those of fine style, is Æginetan; and the coins show a considerable lowering of weight. The later coins follow the Attic talent. Judging from their art, none of the older class can be much more recent than B.C. 370, nor any of the later, much earlier than B.C. 320. One thing is certain, that there is a gap between the coins of the two systems which corresponds very well to the reign of Alexander, some of whose coins may be ascribed, on very probable grounds, to Cretan cities.

Of the island of Crete, generally, there are Roman silver coins of the earlier emperors, some of which are of fine work for the period. The inscriptions are either in Latin, or partly in Latin and partly in Greek. In the autonomous civic series there are didrachms of Aptera, called on its money Aptara. The obverse bears a female head wearing a tiara, and the reverse a warrior before a sacred tree.[1] Of Chersonesus, the port of Lyctus, called on the coins Chersonasus, there are didrachms of fine style, and sometimes of fine work also. The obverse has a head of Diana Britomartis, who had a temple here;[2] and the reverse bears either Apollo with his lyre, or Hercules striking with his club. The pieces with the latter reverse are essentially identical with the fine coin hitherto attributed to the Arcadian Stymphalus which we have lately noticed. The series of silver coins of Cnossus is of great interest and beauty. This city is said to have been the capital of the ancient Cretan kings, and its coins show that it must have been a wealthy place. The oldest coins are of a very archaic style, and probably anterior in time to the expedition of Xerxes, and certainly not later. One of these, a didrachm, has on the obverse the Minotaur, portrayed as a man with apparently a bull's head, kneeling on one knee; and on the reverse the Labyrinth, represented by an intricate pattern. Another didrachm, of about the same time, has on the one side the Minotaur, who has here undoubtedly a bull's head, and on the other a head, which appears to be that of a female, within a labyrinthine border. The head, which is probably that of Ariadne, being put for a person, and the border for the Labyrinth, are instances of archaic feeling. The antiquity of these coins disproves the supposition that the Labyrinth was an invention of the later poets, as there is no mention of it by Homer, Hesiod, or Herodotus; a supposition which has led to the conjecture that the idea is of Egyptian origin, and fixed to this place on account of the natural excavations in its neighbourhood.[3] The coins show that the myth is older than Herodotus; and it may be observed that the Egyptian Labyrinth, both from the evidence of ancient writers and that of its lately-discovered remains, does not appear to have been what is generally understood by a labyrinth. Further, it is doubtful if Homer do not in one place allude to the Cretan Labyrinth.[4] Of the early part of the time of fine work are didrachms with, on the obverse, the head of Proserpine, and on the reverse the head of a bull, for the Minotaur, in a labyrinthine border, or else only a conventional pattern for the Labyrinth. One of these is, on the obverse, in excellent style. These are succeeded by coins of the most beautiful design and execution. They have on the obverse a head of Juno wearing a tiara, and apparently represented as young; and on the reverse the Labyrinth, which here has a rectangular form, and is a maze. The head is of great beauty; its youthful and soft character is probably an effect of Cretan art, but it may refer to the tale that Juno was married near this town.[5] The didrachm and drachm of these types are known. Of a later time there are tetradrachms on the Attic standard, with, on the one side, the head of Apollo, and on the other the Labyrinth, represented of a circular form; or the head of Jupiter, and the rectangular form of the Labyrinth. There are interesting coins of Cydonia. Their types constantly refer to the myth of Cydon, son of Apollo by Acacallis, daughter of Minos. The money of Eleuthernæ must also be mentioned.

Gortys, or Gortyna, is represented by most remarkable coins, which generally allude to the myth of Europa. Didrachms of about B.C. 500 have on the obverse Europa carried by the bull, and on the reverse a lion's scalp, in linear and incuse squares. Colonel Leake describes one belonging to Gen. Fox, with nearly this general type, bearing on the reverse a retrograde inscription in archaic characters, ΓΟΡΤΥΝΟΣ ΤΟ ΣΑΙΜΑ[ΣΗΜΑ],[6] where σῆμα probably means "badge" or "ensign," and not "type;" for the last rendering would not be in accordance with the principles of the inscriptions of Greek coins. These pieces are followed by a remarkably fine class of spread Æginetan didrachms, the types of which relate to the myth of Europa. The best are of the early part of the period of good art, at the time at which perfect skill of handling had been attained. These have on the obverse Europa seated in a pensive attitude on the trunk of a tree, doubtless the sacred plane at Gortyna which was said never to shed its leaves, mentioned by Pliny;[7] and on the reverse a bull suddenly turning his head, as if stung by a fly. Nothing in Greek art exceeds the skill and beauty of these designs. The truth with which the tree is sketched, and the graceful position of the forlorn Europa, are as much to be admired as the fidelity with which the bull is drawn, even when foreshortened, sharply turning his head, with his tongue out, and his tail raised. These designs, beautiful in themselves, are strikingly deficient in fitness, and afford equally strong illustrations of the excellencies and the one great fault of the art of Cretan coins. Many pieces of the same class are of rude execution, but a fine style is evident in all. There is a tetradrachm with the types of the late Athenian ones, from which it differs only in the name, and in having the badge of a butting bull. The coins of Hierapytna are chiefly remarkable for bearing the representation of a date-palm. Of Itanus there are fine early pieces, and others of the best period. Lyttus, as its name is written on the coins in the Cretan form, instead of Lyctus, is represented by many silver coins, chiefly archaic Æginetan didrachms, having on the obverse a flying eagle, and on the reverse a boar's head.

The coins of Phæstus form an interesting series. Among the didrachms are some of admirable work, with, on the obverse, Hercules slaying the Hydra with his club, and on the reverse a bull, excellently drawn. Others, also of fine work, have on the one side Hercules seated on the ground, and on the other a bull within a wreath. The most remarkable coins of Phæstus are, however, those that bear representations of Talos, the man of brass, said to have been made by Vulcan. One of these is an Æginetan didrachm, on which he is portrayed as a winged youth, naked, bearing in each hand a stone, and in a combatant attitude. This figure is accompanied by his name. A similar design is seen on a copper coin. The reader will recollect the accounts which ancient writers give of Talos, and especially that of Apollonius Rhodius (*Argonaut.* iv., 1638, *et seq.*), who relates that he prevented the Argonauts from landing in Crete by hurling stones at them, until he was destroyed by the artifice of Medea. These coins afford important illustration to such scanty and less authoritative notices, and have the advantage, as usual, of addressing us by representation and not by description. Instances of this kind show convincingly the great value of numismatic knowledge in the study of Greek mythology. Of Polyrrhenium, or Polyrrhenia,[8] there are many coins; the early ones are fine, and should rather be called of the people than of the place, since it is said that at the period to which they undoubtedly belong the city was not built, and the Polyrrhenians dwelt in villages,

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[1] *Numismata Hellenica*, "Insular Greece, pp. 3, 4.

[2] Comp. Hoeck, *Kreta*, vol. i., p. 56, *et seq.*

[3] Strabo, lib. x., cap. 4.

[4] *Il.* xviii. 590, *et seq.* It is, perhaps, of little importance that the Cnossians in after times showed a so-called sculpture in white stone ascribed to Dædalus, representing the dance of Ariadne, a work to which Homer was here said to allude. (*Paus.* ix. 40.)

[5] Diod. Sic. v. 72.

[6] *Numismata Hellenica*, "Insular Greece," p. 18.

[7] Plin. *Hist. Nat.* xii. 5.

[8] The name of the place or people on the coins has but one P.

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by which we can scarcely understand a straggling and unwalled town.[1] There are interesting coins of Priansus and Rhaucus, both with representations of Neptune. Of Sybrita, or Sybritia, we must notice a didrachm of the finest work, bearing on the obverse Bacchus or a bacchic figure, with a thyrsus carried by a panther, and on the reverse Hercules drawing on his right buskin.

Eubœa.

The coins of Eubœa are plentiful, but their types are not very various. All, however early, are on the Attic standard, and no numismatic indication of a distinct Euboic talent has yet been discovered. Of Eubœa generally, silver and copper coins are known. The former are of the early part, and the rest of the period of good art, but principally of the latter. The obverse has a female head, probably of Venus, and the reverse, the head of a sacrificial bull. Carystus is represented by early didrachms with, on the one side, a cow suckling a calf, as at Dyrrhachium, and on the other a cock; and by later pieces with the head of Hercules bearded, in the lion's skin, and a palm-tree or other device. Of Chalcis there are drachms with the head which is probably that of Venus, and an eagle destroying a serpent, some of which are fine, although not very remarkable for their art. There is an early tetradrachm of Eretria, bearing on the obverse a bull as if stung by a fly, and with a bird standing on his back, and on the reverse a cuttle-fish. Among the later coins no very fine pieces are found. Of Histiæa there are many small silver coins, which appear to be drachms and tetrobola. The obverse-type is, as we think, the head of a bacchic female (for it can scarcely be of the androgynous Bacchus), and is sometimes very beautiful; and the reverse-type is a female seated on a prow, and holding a mast. Most of these coins are of the fine period, but some are late. In the copper series there are also pieces of good style.

Ceos, &c.

Among the other islands classed after Eubœa, Ceos is especially worthy of note. There are coins which have the name of the people in general, and others of the cities of Carthæa, Coresus or Coresia, and Iulis. The silver money of Coresus is wholly of a very early time, for we must assign it to the sixth and seventh centuries B.C., carrying its oldest pieces as far back as near the commencement of Greek coinage. The weight is Æginetan; and there are didrachms and smaller coins. The usual obverse-type is a cuttle-fish and dolphin, and the reverse bears an incuse pattern. Of the coins of Melos the common obverse-type is a fruit, probably a pomegranate. Those who expect, from the excellence of the works of art that have been found in this island, a corresponding beauty in its coinage, will be disappointed, as at Athens. Naxos is represented by early Æginetan didrachms and coins of the fine period, the latter being chiefly copper pieces of remarkably delicate and good work. The types are bacchic. Of Paros the silver money is plentiful, but not very fine; it consists chiefly of Attic didrachms. There are very early Æginetan didrachms of Siphnos, and smaller archaic coins. Some of the copper pieces are of the best period, and very fine. Of Tenos there are silver coins of the good time, but of poor work. The head of the bearded Jupiter Ammon occurs on tetradrachms following the Attic standard, and on smaller pieces, that of the young Ammon, laureate as well as horned, which shows the reasonableness of concluding that the two representations are of the same divinity.

Pontus, &c.

The coinage of Asia commences with that of Asia Minor. The first provinces are Bosporus and Colchis, the coins of the cities of which are few and unimportant. The coins of the cities of Pontus are more numerous, and although none of them are archaic or deserve to be characterized as fine, the style of some, both of silver and of copper, is not bad. The general series is of copper pieces, which are sometimes large and usually thick, and are of more careful work than those of Greece Proper. The only place meriting especial notice is Amisus, which alone of the cities of Pontus seems to have issued autonomous silver coins. These were continued under the emperors in the form of Greek denarii, that is, Roman denarii with Greek inscriptions. The common subjects of the copper money of this place relate to the myth of Perseus and Medusa. The series of the kings of Pontus and Bosporus has, as its first interesting coins, those of the famous Mithradates VI., king of Pontus, of whom there are staters and tetradrachms. The portrait on the best tetradrachms is extremely fine, and, as a portrait, scarcely excelled in the whole class of Greek coins. Even as a design it has great merits; and this is the more remarkable if we consider the low period at which it was struck. The treatment of the hair has been well explained by the supposition that the head was copied from a statue in which the king, who is said to have been a very skilful rider and charioteer,[2] was represented driving; an opinion which derives some support from the apparent allusion by Pliny to a work or works of the kind.[3] The subsequent coins are not interesting. They are of the remaining part of the kingdom of Pontus, and of all that of Bosporus until near its close, probably not very long after the time of Constantine the Great. The gold and silver coins soon became Roman aurei and denarii in their weight. The gold degenerates into electrum, and the silver is supplanted, though later, by potin or other very base metal. These coins bear dates in the Pontic era.

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Paphlagonia and Bithynia.

In Paphlagonia we must especially notice the coins of the cities Amastris and Sinope. The silver pieces of the former place bear a female head, in a laureate Phrygian bonnet, probably representing Amastris the founder. On the late copper money the bust of Homer occurs. There are also copper coins of the imperial class. The silver pieces of Sinope are plentiful, and of fair work. There are copper coins of a Pylæmenes, king of Paphlagonia, but it is not known to which of the sovereigns bearing that name they should be assigned. Bithynia is represented by a more important series. Of the country generally there are Roman silver medallions, of the weight of low Attic tridrachms, with Latin inscriptions, and imperial copper pieces with Greek inscriptions. The ordinary silver coins of Chalcedon strikingly resemble, on both sides, the early ones of Byzantium, a circumstance confirmatory of the statement that the two cities were colonized at nearly the same time from Megara. Of Cius, also called Prusias ad Mare, there are fine silver pieces: the latter name occurs on some of those in copper. Hadriani and Hadrianotheræ issued autonomous copper coins. Of Heraclea there are silver coins of good work of the fine period; these are Æginetan didrachms, and smaller pieces apparently on the same standard. The obverse-type is a head of Hercules, either bearded or beardless, in the lion's skin; and the most interesting reverse-type, a female head wearing a tiara on which are three turrets, is probably that of the town personified. Of the tyrants of Heraclea, there are silver coins of Timotheus and Dionysius ruling together, and of Dionysius reigning alone. Of the imperial class, there is a large series of Nicæa, and there are many coins of Nicomedia. The series of Bithynia closes with the money of its kings, consisting of Attic tetradrachms and copper pieces. The tetradrachms bearing the name of Prusias are probably of Prusias I. and II., for there is some difference in the portraits. The copper coins with the same name, some of which are fine, cannot be otherwise classed than to both kings, since we do not know by which of the two they were issued. Of Nicomedes II. and III. there are only tetradrachms.

Mysia.

The fine Greek coinage of Asia may be considered to commence with Mysia. Cyzicus is in numismatics a most important city. From it the Cyzicene staters derived their name, which appears to have been used as a general appellation of the electrum staters of the west coast of Asia Minor, although those of Phocæa were distinguished. Some of the known specimens of these coins, as well as of the hectæ, were doubtless struck at Cyzicus; but we have thought it best to group the whole class to which they belong together, until it is more certainly classified. The silver coinage of this town comprises archaic but not very old pieces, and others of early fine work, but of somewhat archaic style, having on the obverse a half-boar, behind which is a fish, and on the reverse a lion's head in profile, within an incuse square. Of the best art there are most beautiful tetradrachms of the Phœnician or Persian talent. The obverse bears a head of Proserpine, with a veil on the back wound round her hair, and in the hair ears of corn. This is an example of the best Greek art, equally simple, delicate, and graceful. Such a union of beauty with breadth and simplicity is very rare, especially in the representation of female heads. Above the head is the inscription ΣΩΤΕΙΡΑ, which may be compared with ΚΟΡΗ ΣΩΤΕΙΡΑ ΚΤΖΙΚΗΝΩΝ on a late copper coin, accompanying a head which is probably that of the younger Faustina in the character of Proserpine. The reverse-type of the fine tetradrachms is a lion's head in profile above a fish. These were followed, after a long space, by coins on the Attic weight; for there is a tetradrachm on that standard resembling those of the later Macedonian kings. Some of the autonomous copper coins are fine, but most are of a low period, probably having been issued just before and under the Roman domination. The late pieces are, however, sometimes of good work for their time. There are also many imperial copper coins.

The money of Lampsacus must next be noticed. In gold there are fine staters, adjusted apparently to the standard of the darics rather than to that of the Attic talent; although, from the small difference in weight, this is hard to determine. One is very fine, though not of the highest art, and remarkable for the peculiar style of the design of its obverse. This is the head of a bearded man, with long dishevelled hair, and covered with a conical cap bearing a wreath. It may perhaps be a head of Neptune. The

[1] Strabo, lib. x., cap. 4. As, however, the city built by the Achæans and Lacedæmonians is here described as strong, it is possible that the villages which it supplanted really formed a straggling town without walls.

[2] Appian. *Mithr.* § 112.

[3] Plin. *Hist. Nat.*, lib. xxxiii., § 54.

Greek Coins.

reverse has the fore-part of a winged horse, the wing being curled, and the body terminating in what seems to be a kind of fin, so that the monster would appear to be a sea-horse. The old silver coins have on the obverse a Janus-like combination of two female heads. Of the good period there are some small pieces; and there is also an Attic tetradrachm of late time, showing the abandonment of the old standard, which was probably Phœnician. The autonomous copper money is not very important. Of Parium there are silver coins of the early fine period, and of rather archaic style. Some copper pieces of good time are remarkable for bearing an altar in perspective, such objects being scarcely ever thus represented until a much later period.

The coins of the great city of Pergamus or Pergamum are chiefly of a late time. There are, indeed, gold and silver pieces of the good period, the former being very rare; but the most numerous silver coins are cistophori, and therefore late. The cistophorus, as we have already shown, is in weight an Attic tridrachm, but it probably came, through the depreciation of the Phœnician tetradrachms of Rhodes and other places, to be considered a tetradrachm, and thus the half and quarter of it were struck, although apparently in no great numbers. All the cistophori are of the kingdom of Pergamus, which afterwards became the Roman province Asia. The oldest were most probably issued under the kings, but the later are of the Roman rule, and we find on them the names of proconsuls or proprætors of Asia, and of proconsuls of Cilicia, from the time at which Phrygia was given to that province. Thus the name of M. Tullius Cicero, as proconsul, occurs on a cistophorus of Apamea of Phrygia, and, with the title "Imperator," on one of Laodicea in the same country, the latter coin illustrating an event narrated by the orator.[1] The obverse-type of these pieces is the *cista mystica*, a basket from which a serpent issues, all within a wreath of ivy; and the reverse-type, two serpents, partly intertwined, and rising on either side of a bow-case, or sometimes, but rarely, of some other object. These proper cistophori are succeeded by coins of the time of the triumvirate of Mark Antony and his colleagues, with a Roman head or heads on the obverse, and serpents on either side of the cista, and of some other object, on the reverse; and these, again, are followed by the so-called imperial silver medallions of Asia, which are of the weight of cistophori. These last have on the obverse either the head of an emperor or that of an empress, and on the reverse various designs, and are of fine work for the period. The earliest are of Augustus, and the latest of Domitian.[2] The copper pieces of Pergamus are numerous, both of the autonomous and of the imperial class, the latter comprising some medallions. The principal coins of the kings of Pergamus are Attic tetradrachms, with, on the obverse, a laureate head, believed to be that of the first king, Philetærus, and on the reverse a seated Minerva. The portrait is often very fine, when it must be considered to be one of the best Greek portraits, and an excellent example of the work of the time. The reverse is probably taken from that of the common tetradrachms of Lysimachus, from whom Philetærus revolted. Although the inscription of the reverse is always ΦΙΛΕΤΑΙΡΟΥ, a monogram or letter sometimes points out the king by whom a particular coin was issued. Besides these tetradrachms, there are copper coins, which, however, are unimportant.

The Troad.

The coinage of the Troad is chiefly interesting from its reference, in its later pieces, to the Trojan War, and the manner in which it thus illustrates the Iliad. We must recollect, however, that this kind of evidence on very late coins cannot be safely held to be independent, except where the type is of an indisputably religious character, and also that, at the Roman time, and a period somewhat earlier, this character is not constant. Hence we must not hastily conclude that the coins show that there was a local tradition of the great contest, nor that they prove its heroes to be mythical. Of Abydos there are silver coins of the early part of the good period, which seem to be adjusted to the Phœnician talent. The drachms have on the obverse an anchor, to which a craw-fish is about to cling; and on the reverse a head of Medusa, with the serpents, which are not usually represented on the coins. There are Attic tetradrachms of a late time, noticeable for their strange fabric, which gives them the appearance of cast coins, and renders them suspicious to those who are unaware of this peculiarity. Alexandria is represented by late Attic tetradrachms, having on the one side a head of Apollo, and on the other, Apollo advancing with bow and arrow, and the inscription ΑΠΟΛΛΩΝΟΣ ΣΜΙΘΕΩΣ ΑΛΕΞΑΝΔΡΕΩΝ, &c. There are later autonomous and imperial coins, in copper, of the Roman colonia. Of Ilium there are likewise late Attic tetradrachms of coarse work, bearing on the obverse the head of Minerva, and on the reverse the same goddess advancing, holding in her right hand a spear, which rests on her shoulder, and in her left hand a distaff, with the inscription ΑΘΗΝΑΣ ΙΛΙΑΔΟΣ, &c. One of the autonomous copper pieces has on the obverse Hector in a combatant attitude, with his name ΕΚΤΩΡ, and on the reverse the wolf and twins, showing that it is of the Roman period. On another copper coin Æneas is represented carrying Anchises, and leading Ascanius. There are also many imperial copper pieces of this place. Of Scepsis, which is said to have been the capital of a Dardanian kingdom for a long period between the fall of Troy and the age of Alexander,[3] there are archaic silver coins; and some of its copper money is of good style. Sigeum was for a great length of time a dependency of Athens; and the common types of its silver coins are accordingly Athenian, although the style of art is different. The island of Tenedos is represented by very early coins, and others of the fine and late periods. The usual obverse-type of all the silver pieces is a Janus-like combination of two heads, probably those of Jupiter and Juno; and the usual reverse-type of all but the oldest is a two-headed axe.[4] The weight seems to be always Attic.

Greek Coins.

Æolis.

In Æolis we may notice that some of the coins of Ægæ are of a very early time, and that the principal type, the head and neck, or fore-part of a goat, is probably connected with the name. The town of Cyme is represented by an important series of silver coins. A few of these are early, but most are fine late Attic tetradrachms, probably first struck not very long after Alexander's time, and perhaps issued for about a hundred years. On the obverse is a female head, perhaps that of Diana, bound with a narrow fillet: the style has some purity and vigour, though yet far inferior to that of the best Greek coins, and thus shows the vitality of art in Asia Minor. The reverse-type is a horse within a wreath of laurel. There are also examples of fair work among the copper coins. Of Myrina there are Attic tetradrachms like those of Cyme, and of about the same period. The obverse-type, which is a laureate head of Apollo, is in a vigorous style. The imperial coins of Æolis are not very numerous.

Lesbos.

The coinage of Lesbos is remarkable for the base material of what we may consider, as a class, to be its oldest pieces. These, although at first heavier, probably represent Æginetan didrachms and divisions, their original weight having been determined on the same principle as that which regulated the weight of the electrum coins of Asia Minor. They are doubtless of the different cities of the island, although it is difficult to attribute most of them. Certain of these early base silver coins, with, on the obverse, two boars' heads facing one another, and on the reverse an irregular incuse square, must be classed to Antissa, as Mr Burgon has determined, since one bears the letters AN in monogram. To Methymna may perhaps be assigned a coin of the kind just noticed, but there is also a silver one of very archaic style, which is, if not anterior to it, at least of the same time. Of a later period there are fine coins of this town. Among the copper pieces we must not pass by one already mentioned, on which Arion and the dolphin are represented. The weight of the pure silver coins of Methymna seems to be always Attic. Mytilene appears to have struck electrum coins, for hectæ are assigned to it, one of which bears the letters ΑΕ. It must be remembered that this was the chief town of the island, and, as Col. Leake supposes, Homer's Λίσβου ἰϋκτιμένην. There are early base coins of this place, and silver of the fine period. The standard seems to be Æginetan. The copper pieces are numerous, and the earliest are of fair style. The very late are interesting, as bearing the names and portraits of benefactors. Mytilene is thus shown to have honoured such persons as heroes or heroines; and one, Theophanes, the friend of Pompey, from whom he obtained for this city, his native place, the privileges of a free state, is indeed even called a god; while Archedamis, probably his wife, is styled a goddess. The imperial coins of Mytilene may also be mentioned: they comprise medallions. There are beautiful copper pieces of Pyrrha of the good period.

Electrum coins of Asia Minor.

The electrum coins of Asia Minor may be best placed between Æolis and Ionia, in the opinion of Mr Burgon, since this position is about the centre of their geographical range. They form a most interesting class, whether we consider the antiquity of the earliest, or the admirable style of the designs of a great proportion, or their

[1] Having conquered the barbarians at Issus, Cicero received this title: "Ita victoriâ justâ Imperator appellatus apud Issum," &c. (*Epist. Fam.* ii. 10.)

[2] See, on the whole subject of the cistophori and imperial medallions, an excellent paper by M. Pinder, "Über die Cistophoren und über die Kaiserlichen Silbermedaillons der Römischen Provinz Asia, von M. Pinder" (*Kongl. Acad. der Wissensch.*), Berlin, 1856.

[3] Strabo, lib. xiii., chap. i.

[4] Aristotle (*ap. Steph. Byz. voc.* Τένεδος) gives a puerile explanation of these types, which Colonel Leake (*Num. Hel.*, "Insular Greece," p. 43) rightly condemns.

Greek Coins.

general importance in reference to Greek mythology. As to their art, it may be truly said that it is impossible to form a fair opinion of the artistic excellence of the coins of the west of Asia Minor without a knowledge of these, which make up the majority of the most carefully-executed specimens struck during the best period. The earliest electrum coins have the appearance of a greater antiquity than any in the whole Greek series; and thus explain the remark of Herodotus, that the Lydians, as far as he knew (for he does not here omit his characteristic cautious mode of expression), were the first who struck money. Although perhaps the first coins may have been struck in Ægina, and others soon afterwards elsewhere in Greece, and this useful invention speedily adopted in Asia, it seems more probable that it was of Asiatic origin; and it should be remembered that the part of Asia to which the electrum class belongs was at this early period subject to the Lydian kings. The oldest pieces are staters and smaller coins, with rude and seemingly unmeaning incuse stamps on the obverse, and on the reverse a mere mark of the rough surface of the anvil. These are followed by coins with a rude design on the obverse, and irregular incuse stamps in a square on the reverse. After a time the art of the designs on the obverse improves, and the reverse is occupied by a quadripartite incuse square, of which each of the divisions is in a different plane. There are many staters and hectæ of this class, which we may call the later archaic, to distinguish it from the older class which precedes it. To the same group must be assigned some hectæ struck towards the close of its period, which are remarkable for having a second and incuse design on the reverse, differing from that on the obverse. The electrum coins of the best period commence with such as are slightly archaic. These have the quadripartite incuse reverse, which is, as far as we know, the invariable reverse of the staters of this whole period. These staters are of pure and excellent style in their designs. The hectæ are unexcelled for breadth and purity of style, combined with the greatest beauty and refinement. They present a most interesting series of heads of Greek divinities. The latest show a slight decline in their style.

Ionia.

In Ionia we must first notice the town of Clazomenæ, the earlier silver pieces of which bear the fore-part of a winged boar. Among the coins issued at a later time, we must notice three examples which worthily support the character we have given the artists of Asiatic Greece. These are, a gold coin of the weight of the third of an Attic tetradrachm, and two silver Attic tetradrachms. The obverse-type of all is a head of Apollo facing, and the reverse-type a swan. The age is about the middle or latter part of the fifth century B.C.; and the head is in the very best Greek style, the swan being not so finely executed. The former is slightly better on the gold coin, where it has a simple grandeur and beauty that gives it a place among the first monuments of Greek art. On the two tetradrachms the head is but little inferior; and it is noticeable that the artist, proud of his work, has inscribed on both (for they are by the same hand, though from different dies) "Theodotus made this" (ΘΕΟΔΟΤΟΣ ΕΠΟΕΙ). There is a tetradrachm, doubtless later, on which the head of Apollo shows an ornate and mannered style. Some of the copper coins are of the good time, and well executed.

Passing Colophon, of which there are archaic coins and others of the fine period, we reach Ephesus. The early silver pieces of this town, which are not of a very remote period, have on the one side a bee, and on the other usually an incuse square, rudely divided into four parts. The most important of the older coins of the fine period are tetradrachms of the Phœnician talent, bearing on the obverse a bee, and on the reverse a date-palm and the forepart of a stag. The principal later coins of the same period are didrachms of a lower weight, and in time a little before the expedition of Alexander. They bear on the one side the bust of Diana, in a beautiful style, but not the finest; and on the other the fore-part of a stag. Of a still lower time there are many cistophori. Some of the autonomous copper pieces display a good style of art. There is a large imperial series, including some coins of silver. Of the latter metal certain are of especial interest, since they bear, although they are evidently of Roman weight, inscriptions stating them to be drachms and didrachms. These are followed by Roman denarii of fine work, with Latin inscriptions. The imperial copper money also presents specimens of good art for the period. There are coins in both silver and copper of Ephesus with the name of Arsinoë, which the city took from the wife of Lysimachus, and bore only during his life. They have the portrait of Arsinoë, which may be compared with that on her Egyptian coins as wife of Ptolemy Philadelphus.[1] The money of Erythræ bears types connected with Hercules. Some of its silver coins, on the Phœnician standard, are of good style; and the autonomous copper pieces are noticeable for the great number of magistrates' names which they bear, indicating the long period during which they were issued. On the coins of Magnesia are subjects connected with the River Mæander. Thus the earlier silver pieces, which have on the obverse an armed horseman galloping, bear on the reverse a humped bull butting, within a circular meander, or upon a straight device of the same kind; so that there seems to be a double symbolic representation of the river. There is also a fine spread Attic tetradrachm, of late time, but of fair work, like those of Cyme; and having on the obverse the bust of Diana, and on the reverse Apollo standing on a meander. Of Miletus there are a few archaic silver coins on the Attic standard, with, on the one side, a lion's head and fore-leg, and on the other a conventional star in an incuse square. The later pieces, which appear mainly to follow the Phœnician standard, are of good and sometimes excellent work. Their obverse-type is a head of Apollo, and their reverse-type a lion looking back at a star. The silver coins of Phocæa are very early, and have on their obverse a seal, reminding us of the derivation of the name of the place. The copper coins are much later, and some of them are in a good style. No early silver coins of Smyrna are known, the pieces in this metal being late Attic tetradrachms, with, on the obverse, a female turreted head, probably that of Cybele, and on the reverse a lion or a monogram, within a wreath of oak. In copper there is a large series, both of the autonomous and of the imperial class. Some coins of the former kind are of fair work. Certain of them have on the obverse a figure of Homer seated; and it was doubtless copper money of Smyrna of this sort which Strabo mentions as bearing the name Ὁμήρειον. Other autonomous copper coins bear on the obverse the head of Mithradates VI., and were doubtless struck when he held the place. The imperial class comprises fine pieces, with portraits of great beauty and merit, and otherwise of good work. Historically the most interesting are those which bear the name of a Vespasianus Junior (νεώτερος), supposed to be a prince of the Flavian family not otherwise known to us. Of Teos there are archaic Æginetan didrachms, bearing on the one side a seated gryphon with curled wings, and on the other a quadripartite incuse square. There are later coins of the earliest good work, and others of subsequent times.

Greek Coins.

Chios and Samos.

Chios and Samos, islands of Ionia, are represented by interesting coins. Of the former there are archaic silver pieces, but the greater number of its coins are of the early fine period. The obverse-type is a seated sphinx with curled wing, and an amphora upon a slightly-raised surface like a shield; and the reverse bears an irregular incuse square of four divisions. The weight is Phœnician. There are later coins in silver, and many autonomous and imperial copper pieces. Some autonomous copper pieces of the Roman period have the value inscribed, thus ACCAPION HMTET, [*sic.*] ACCAPIA ΔΤΟ, ACCAPIA TPIA, and also OBOΛOC, the latter being properly the name of a Greek silver coin. The coins of Samos are on the Phœnician standard. There are numerous tetradrachms, some early, and many of the good period. Their common obverse-type is a lion's scalp; and the early coins have on the reverse the head and neck of a bull, the later, the fore-part. Some of the smaller silver pieces are supposed from their types to have been issued at a time when Samos and Clazomenæ were in alliance.

Caria.

The autonomous civic coinage of Caria is generally poor in art, and even inclining to barbarism. Of the imperial class there are coins of many cities, but no one very large series. The autonomous money of Cnidus, of which the silver follows the Phœnician system, deserves especial mention. The early coins have on the obverse the head and fore-leg of a lion, and on the reverse the head of Venus. The same types continue, but during the time of good art they change places. There are other silver coins of Cnidus, with, on the one side, a Rhodian type, the head of Apollo facing, and on the other the Cnidian head and fore-leg of the lion. These indicate a Rhodian alliance or domination. The money of Halicarnassus includes some silver pieces of the good period. Of Iasus there are silver coins of good but not the best style, having on the obverse the head of Apollo, and on the reverse a youth swimming beside a dolphin which he holds—a type reminding one of the well-known didrachms of Tarentum. Of Myndus there are silver pieces, with, on the obverse, the head of Jupiter, and on the reverse an Egyptian divinity's plumed head-dress. The coins of Nysa, of Stratonicea, and of Tripolis may also be mentioned. The money of the kings of Caria is worthy of note. The weight is Phœnician. There are tetradrachms, didrachms, and drachms, having for their obverse-type a fine head of Apollo, laureate, facing; and for the reverse-type a standing figure of the Carian Jupiter holding a two-headed axe and sceptre. These pieces are of Mausolus or Maussolus, of Idrieus or Hidrieus, and of Pixodarus.

Calymna and Cos.

First of the islands of Caria, Calymna should be noticed. The early silver coins are extremely barbarous, but the later are in a good style. The obverse bears a helmeted male head, in the earlier

[1] See a paper by Mr Borrell of Smyrna (*Num. Chron.*, vol. ii., p. 171, *et seq.*)

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pieces bearded, and in the later, beardless; and the reverse, a lyre. Cos affords an important series. The standard of the silver pieces appears to be Phœnician, but if so, the weight of the earliest is very heavy. The oldest tetradrachms have remarkable types:

Cos.

that of the obverse represents a naked male figure dancing and beating a tambourine before the tripod of Apollo, and the reverse is occupied by an irregular incuse square, divided diagonally, and having a crab in the centre. The obverse-type is in a very fine late archaic style. Among the later coins we must notice, as the most beautiful, although not severe in its treatment, one with, on the obverse, a head of Hercules bearded, and on the reverse a head of Ceres veiled. There are also small pieces of a subsequent time, which bear on the one side a head of Æsculapius, resembling that of Jupiter, and on the other a serpent. Many copper coins also bear types relating to this divinity. The imperial money is insignificant.

Rhodes.

The island of Rhodes takes an important place in numismatics. In Homer's time, three cities, Lindus, Ialysus, and Camirus, divided its territories between them. After having existed several centuries, these cities united to found Rhodes, and ceased to possess separate laws. Strabo places this event in the course of the Peloponnesian War (*κατὰ τὰ Πελοποννησιακά*), and gives another indication of its date when he says that the architect employed was Hippodamus of Miletus, who built the Piræeus of Athens, for the latter work was executed about B.C. 475. It may therefore be supposed that Rhodes was founded not very long, perhaps as much as twenty years, before the Peloponnesian War, which began B.C. 431. These particulars entirely agree with the numismatic evidence. The coins of the three cities, if we include those attributed to Astyra, are generally of archaic fabric, and in no case late; while those of Rhodes do not in style reach earlier than the middle of the fifth century B.C. The coins of Camirus and those of Ialysus, the latter seeming always to commemorate alliances, are worthy of careful study. Of Rhodes there are gold staters of Attic weight, and smaller pieces, all of a low period. The silver coins form a large series. The pieces struck before Alexander's expedition may be considered as generally of the good period, although some of them are archaic; and those issued after his reign may be assigned to the time of decline. During that reign his regular coinage was struck at this city. The obverse bears a head of Apollo, facing in the large coins, and usually in profile in the small. The earlier are chiefly to be distinguished by the facing head of Apollo being bare, and the later, by its being radiate. On the reverse is a rose, almost always represented in a side view, but sometimes as seen from above. After a very careful examination of many examples, we are firmly convinced that this is nothing but a single rose. It has been suggested that it is a pomegranate flower (*βαλαύστιον*); but the coins seem to us absolutely to overthrow this theory, although supported by the opinion of Colonel Leake. No doubt there is a certain degree of conventional treatment in the representation, but not enough to render its meaning in any degree doubtful. Some of these coins are fine, although most of them show, in the head, a degree of harshness. The weight is Phœnician, and becomes very low. The autonomous copper coins are similar to the silver; a few are fine, and some are very large. Those of the imperial class are unimportant.

Lycia.

Entering Lycia, we are in a more Asiatic region than any through which we have passed. The earlier coins have a peculiarly local character in most instances, and are no doubt of the Persian domination. It seems probable that their issue ceased somewhat before Alexander's expedition, for we can scarcely bring the latest quite as low as that event. There can be no question that, here as elsewhere, a Greek coinage was then introduced, first struck by Alexander, and afterwards by the cities. The earlier coins are principally of silver, but copper pieces occur. Some of the former have a very archaic aspect; and the style of all would be called archaic elsewhere, but here the eastern character of the devices must be taken into account. The types present a union of Greek and oriental designs, the most common of which is one probably of the latter class—the so-called triquetra, an object resembling a ring to which three hooks are attached. A man-headed bull with curled wings is also to be noticed. The inscriptions are in Lycian characters, except in the case of the early pieces of Phaselis, which have Greek letters. The coins with Lycian inscriptions have not been satisfactorily attributed. The standard is probably Phœnician, but this cannot be regarded as certain. Sir Charles Fellows has published a list of all the specimens of this class known to him, with engravings of the greater number.[1] The later coins, or such as were struck after Alexander's time, are of inferior interest to those which we have just noticed. The common types are, for the obverse the head of Apollo, frequently in rather an androgynous character, and for the reverse, a lyre in a shallow incuse square. These occur on small silver coins of the cities Cragus, Limyra, Massicytes, Patara, and Phaselis, the earlier coins of the last of which we have already noticed. The imperial pieces of Lycia, in silver and copper, form a very small class.

Greek Coins.

Pamphylia.

The older of the autonomous coins of Pamphylia show oriental influence, although this is principally displayed in the weights and inscriptions. The imperial money consists of copper pieces, which are not of great importance. Of Aspendus there is a large series of silver coins. They appear, from their weight, to be double silver darics, equal to two-thirds of the Phœnician tetradrachm. The inscription is in a Pamphylian form, and written in Greek characters. The common coins are generally of the early part of the fine period; they have on the obverse two wrestlers engaged, and on the reverse a slinger discharging a stone, with, in the field, a triquetra formed of three legs, like that represented on coins of Syracuse. The autonomous series of Perga is not important. Of Side there are archaic pieces of the weight of double silver darics. Their obverse-type is a pomegranate fruit (*σίδη*) above or upon a fish. Of a subsequent period are early fine silver coins of the same denomination as the older ones, although lighter. Their obverse-type is Minerva holding an owl or a little Victory, with a pomegranate in the field; and their reverse-type, a male figure sacrificing. They bear an inscription in Sidetan letters, which differ from those on the coins of Aspendus—some being apparently Phœnician, while others are Greek. After these coins are Attic tetradrachms, bearing on the one side the head of Minerva, and on the other a Victory, with a pomegranate in the field. They are very similar to the tetradrachms of Amyntas, King of Galatia.

Pisidia, &c.

In Pisidia the only important autonomous series is that of Selge. The principal coins are pieces of the weight of double silver darics. Their types are essentially the same as those of the silver coins of Aspendus, already noticed. On the one side are two wrestlers, and on the other a slinger, who here appears to be Hercules, with a triquetra in the field. The inscription is Greek. The autonomous copper money of Termessus must also be noticed. The imperial coins of Pisidia are not very numerous. Of the cities of Isauria there are only a very few imperial copper coins; and in Lycaonia there are some autonomous pieces of Iconium, and a very scanty imperial series of that and other places.

Cilicia.

Cilicia has a higher numismatic interest. The autonomous coins display Persian influence, even if we exclude, as of the oriental class, the money of the satraps. The weight is evidently on the Phœnician standard, and the principal denomination is generally what we may term the double silver daric. The imperial coins are not very important. Of Celenderis there are archaic and early fine pieces, of the weight of double silver darics. The older are not of a remote time, and some of them are remarkable for the excellence of their style and execution. The obverse-type is a naked horseman seated sideways, and the reverse-type is a goat crouching forwards. The coins of the good period present no great differences. Of Mallus there are silver coins, which are either partly or wholly Persian in their types. These are of the same denomination as the pieces of Celenderis just noticed. So also are the silver coins of Nagidus, which are of fine or fair style, as well as those of Soli, some of which are very early, but others of the period of good art. The autonomous silver coins of Tarsus bear witness to its ancient wealth. The earlier are on the Phœnician standard, and the chief piece is of the weight of a double silver daric; and the later follow the Attic standard, and the principal denomination is a tetradrachm. The former are of the Persian period, and the latter of that of the Seleucidæ. The inscriptions of these silver coins are Phœnician, and their types have an oriental character. The Phœnician coins having the weight of double darics have on the obverse Baal of Tarsus seated, and on the reverse a lion seizing a stag; and the Attic tetradrachms have the same obverse-type, and the reverse-type of a lion walking. Among the devices of the copper coins is the so-called monument or, incorrectly, tomb of Sardanapalus. The imperial coins include some base silver or potin pieces. The coins of satraps struck at Tarsus should be referred to the Persian series. It may be noticed that there are copper coins of Tarcondimotus and Philopator, kings of Cilicia.

Cyprus.

The coins of Cyprus form a small but remarkable series. They do not commence at a very early period, for one of the oldest is struck upon a silver coin of Aspendus, with the types of the wrestlers and slinger. The usual metal is silver. The types frequently refer to the worship of Venus. The inscriptions are in Cyprian characters; but the pieces of one place, if the attribution be right, bear Greek letters, and there is an instance of Phœnician letters on the same coin with Cyprian ones. The art is chiefly remarkable for its oriental character, which gives the coins an

[1] *Coins of Ancient Lycia before the Reign of Alexander, with an Essay on the relative Dates of the Lycian Monuments in the British Museum*, by Sir Charles Fellows, 1855.

Greek Coins.

archaic appearance that more satisfactory evidence does not corroborate. The denominations appear to be Phœnician, and there is no doubt that the heaviest is of the weight of two silver darics. Pieces having on the obverse a ram lying down, and a reverse, either perfectly plain, or else bearing a ram's head or a kind of *crux ansata*, are assigned by the Duc de Luynes to Amathus, with two exceptions. The coins with the Greek inscription MAP, before alluded to, he attributes to Marium. To Salamis he classes coins of which two types are worthy of note. One of these represents a female seated on or carried by a bull, and the other a figure, apparently also that of a female, carried by a ram. The former type connects the myth of Europa with the worship of the Cyprian Venus and Astarte; and the latter connects these again with the story of Helle, and the recumbent ram on the Cyprian coins with the famous one which bore the Golden Fleece. There are a few copper coins of this class. The Duc de Luynes has published an excellent essay on these coins of Cyprus.[1] A few pieces are known of the kings of Cyprus. Of the Greek imperial class there are base silver and copper pieces of the island generally, on which occurs, in both metals, a remarkable reverse-type representing the famous temple of Venus at Paphos.

Lydia.

The coinage of Lydia is chiefly of copper pieces, the majority of which are either actually imperial or struck during the imperial period. The autonomous copper coins of Blaundus may be mentioned, as well as those of Magnesia ad Sipylum. One of the latter place is of the highest interest, from its bearing a fine portrait of Cicero, which is no doubt nearly or quite contemporary. It is of good work, resembling in that respect the Roman money of the earlier emperors. The autonomous copper coins of Philadelphia must also be noticed. Of Sardis there are cistophori, as well as many copper pieces. Some of the latter, of the imperial class, display good work. There are copper coins of Thyatira, both autonomous and imperial, some of the latter being of fine work for the period to which they belong. Tralles is represented by cistophori and by copper coins. There are some uncertain Lydian coins, which were probably struck at Sardis by a Lydian king, perhaps Crœsus. They are of both gold and silver, and bear on the obverse the fore-part of a lion facing the fore-part of a bull, as if attacking it, while the reverse is occupied by an incuse square rudely divided into two parts. The gold coins weigh the same as the darics, and the principal silver ones, like the so-called silver darics, one-third less. The type is manifestly of an oriental, if not a Persian character, being only another form of the common one of a lion seizing a bull. It would be hasty, however, to conclude that the coins are of the time following the overthrow of Crœsus by Cyrus.

Phrygia.

The coinage of Phrygia is chiefly of the Roman period, and its imperial pieces are numerous and interesting. Of Apamea Cibotus, more anciently Celænæ, there are cistophori and autonomous copper coins, some of which are of a fair style for the late time at which they were struck. The imperial series contains the remarkable pieces which have been supposed to bear a representation of the ark of Noah. These are of Septimius Severus, Macrinus, and Philip Senior, and have on the reverse an ark in the shape of a boat or chest, with two persons either within or near it, and upon it the letters NΩE or NΩ. It is not reasonable to suppose, as has been frequently done, that these coins directly refer to the Noachian Deluge. It does not seem possible that any Jewish or Christian community would have been able, at the time when these pieces were struck, to fix types of the public money of a pagan town, and it is by no means likely that any local tradition would have preserved the actual name of Noah. The letters which appear at first to be that name may, however, be part of the name of the people, ΑΠΑΜΕΩΝ, or they may have been added by tooling in modern times, but as to this we cannot speak positively, not having seen any of the specimens. In either case the designs would do no more than refer to the story of Deucalion, and so indirectly to the Deluge of Noah. The appellation *κιβωτός* given to the town implies some connection with an ark; and it is very probable that the tradition of a great flood would be stronger in Phrygia than in Greece Proper, from the former country being much nearer the site where the ark must have rested than the latter. There is another coin of Apamea with a remarkable reverse, which we have already described in an earlier place. It is one of Septimius Severus, with the type of Minerva playing on the double pipe. Other pieces also have designs relating to the myth of Marsyas, as one of Hadrian, on which he is represented playing on the double pipe. Of Cibyra there are silver coins of a base style, and copper pieces; and of Hierapolis, copper coins, including some of a fine late style. Laodicea is represented by cistophori and autonomous copper coins, of which last some are of fair style, as one with the bust of Μήν or Lunus upon a crescent, wearing a Phrygian bonnet wreathed with laurel. Some of the early imperial pieces bear fine portraits. On the copper coins of Prymnessus the bust of Midas is represented wearing a Phrygian bonnet.

Greek Coins.

The autonomous coinage of the cities of Galatia is very unimportant, and the imperial series is not extensive. There are coins of several kings, of whom the principal one is an Amyntas, believed to be the contemporary of Strabo. The gold money attributed to him is of doubtful authenticity. His silver pieces are light Attic tetradrachms, greatly resembling those of Side. There are imperial copper coins of Galatia generally.—The autonomous civic coinage of Cappadocia is very scanty; but of the imperial class there is one long and interesting series—that of Cæsarea. It comprises silver coins of somewhat base metal. These are of several denominations, of which the basis seems to be a Greek denarius, than which there is a lighter piece as well as heavier ones. They were struck for about 200 years, terminating after the reign of Geta. Among the reverse-types must be noticed a Bactrian camel, and the sacred mountain Argæus. The latter subject is frequent on copper as well as silver coins; and on the former the mountain is sometimes represented as if upon an altar. The money of the kings of Cappadocia is also worthy of note. It consists of silver pieces, which appear to be Attic drachms, and were struck during a period extending from about the last quarter of the third century B.C. to the time when Cappadocia was made a Roman province. The coins bear portraits which are sometimes well executed. There are a few copper pieces of the ancient kingdom of Armenia.

Galatia and Cappadocia.

Syria.

The coinage of Syria commences with the series of the Seleucidæ, which, for the excellence of its portraits, may, as a whole, take the first place in the class of Greek regal money. It comprises a few gold pieces; its silver coins, which are chiefly tetradrachms, are abundant, and there are many copper coins. The reverse-types present no great variety, and are usually of little interest. The weight of both gold and silver coins is Attic, excepting those in the latter metal issued by the Phœnician mints, which, save the earliest pieces of Sidon, which are on the Attic weight, follow the standard of the Ptolemaic coins. Of Seleucus I. there are gold staters. Most of his tetradrachms have the same types as those of Alexander the Great, with sometimes this deviation, that the Jupiter on the reverse holds a Victory instead of an eagle. Some, however, have on the obverse a head, doubtless that of Seleucus, in a close helmet, mainly formed of the skin of a bull's head, with the horn and ear. Other tetradrachms have on the reverse Minerva fighting in a quadriga of elephants, with, in the field, an anchor, the symbol of Seleucus. It is remarkable that, under the next sovereign, Antiochus I., tetradrachms were still struck bearing Alexander's types, but with, in the only example we have seen, the same variation of the reverse-type as in some of the similar coins of Seleucus I. The ordinary tetradrachms bear the king's portrait and Apollo seated on a cortina, a common reverse-type of the earlier Seleucidæ. The tetradrachms of Antiochus II., Seleucus II., Antiochus Hierax, and Seleucus III., are only interesting for their portraits. Antiochus III., or the Great, struck gold money, for there is an octodrachm, of course on the Attic standard, among his coins. The portrait on the tetradrachms varies according to his age: sometimes it is fine. The tetradrachms of Seleucus IV. need not be noticed, except as having portraits. Those of Antiochus IV. have two types of obverse, both of which are fine heads: one of these is undoubtedly that of this king; the other, which is bearded, may be that of Jupiter, although it has a resemblance to the portrait. The tetradrachms of Antiochus V. and Demetrius I. have portraits. Of Alexander I. there are not only Attic tetradrachms, but also Ptolemaic of Tyre and Berytus, having an eagle on the reverse, the characteristic of the class, plainly showing its Egyptian origin. A tetradrachm of Sidon has Attic weight and a Syrian reverse-type. The portrait on one of Tyre is fine. On the earlier tetradrachms of Demetrius II. the king's head is beardless, but on the later, bearded. One of them bears the design which has been supposed to represent the monument of Sardanapalus. Of this Demetrius there are also Ptolemaic tetradrachms of Tyre and Sidon. The portrait of Antiochus VI. on his tetradrachms is very fine. That of Tryphon, upon an extremely rare coin of the same denomination, is remarkable for its strange helmet, having the horn of an ibex projecting in front. The tetradrachms of Antiochus VII. and of Alexander II. have portraits; and those of Cleopatra with Antiochus VIII., bear heads of the queen and king, one behind the other. Seleucus V. is represented by copper coins; there are tetradrachms with portraits of Antiochus VIII. alone, Antiochus IX., Seleucus VI., Antiochus X., Antiochus XI., Philip, Demetrius III., and copper coins of Antiochus XII. The tetradrachms of Tigranes have the bust of the king wearing a strange oriental head dress. The series closes with copper pieces of Antiochus XIII.

In Commagene we may notice the autonomous and imperial cop-

[1] *Numismatique et Inscriptions Cypriotes*, par H. de Luynes, 4to, Paris, 1852.

Greek Coins.

per coins of Samosata, and the pieces of Zeugma of the latter class. There is also copper money of the kings of Commagene. In Cyrrhestica there are unimportant autonomous copper coins, and not very numerous imperial pieces in the same metal. Those of Bercœa, Cyrrhus, and Hierapolis, of the latter class, may be mentioned. There are a few autonomous copper coins of Chalcidene, but Palmyrene is not represented. Copper pieces are indeed known, purporting to be of the famous Zenobia, struck at Alexandria of Egypt; but those we have examined are doubtful or false. In Seleucis and Pieria the series of the great city of Antioch on the Orontes must be first noticed. There are autonomous copper coins, but those of the imperial class are far more numerous and important. They form a very large series, extending through nearly the whole period of Græco-Roman coinage. The types are not of much interest, and are very few in number; while the art of the coins is generally rude, although some of the silver pieces are in a fair style. The series has, however, a historical value, in showing us what emperors here struck money, and therefore ruled in Syria. The silver coins are of base metal, which becomes potin, and even at last copper washed with silver. In weight they are very low Attic tetradrachms, each being equivalent to four denarii of the early empire. They do not lose weight by degrees, but the quantity of pure metal constantly decreases. They commence under Augustus, and last as late as the time of Volusian. The Era according to which the earlier are dated is the Cæsarian, except during the reign of Augustus, and part of that of Tiberius, when the Actian was used. After Nero the tetradrachms bear no such date, the emperor's tribunitian year taking its place. The obverse bears the head or bust of an emperor or empress, and the reverse, the city seated, or an eagle upon a thunderbolt or club. The eagle, with sometimes a symbol or letter between its legs, becomes at a late period the constant reverse-type. There are copper coins having Greek inscriptions, and others contemporary with them having Latin inscriptions, although after a time the two kinds merge into one, with Greek inscriptions, except that the Roman S. C. in Latin letters is added. It is to be remarked, that on some pieces of the last class the city is called a colonia, having been constituted one by Caracalla. The autonomous copper coins of Apamea may be noticed, as bearing an elephant for a reverse-type. Of Laodicea we must mention late tetradrachms, doubtless of the Roman period, and of the same standard as those of Antioch: their obverse-type is a turreted and veiled female bust, personifying the city. There are also autonomous and imperial copper coins. Seleucia is represented by late autonomous tetradrachms of the same kind as those of Laodicea, and with the same type on the obverse, as well as by copper coins. In Cœlesyria there are some copper coins of Damascus, both autonomous and imperial, and others in the same metal of a king Aretas. It is not certain to which, if any, of the sovereigns bearing his name, mentioned in history, this Aretas corresponds. In Trachonitis there are only a few imperial copper coins of Cæsarea Panias; and in Decapolis there is a small number of pieces, of the same class and metal, of some of the cities.

Seleucis and Pieria, &c.

Phœnicia.

The money of Phœnicia is more interesting than that of the countries last mentioned. Here the autonomous coinage again becomes important, and affords us some indications of the ancient power and wealth of the great commercial people from whom the region takes its name. The earliest coins, however, are classed with those of Persia, and were no doubt mostly struck under Persian rule; while such as were probably issued independently are sufficiently oriental in character to belong rather to that kind than to the Greek. Of Berytus there are copper coins both autonomous and imperial; those of the latter sort are numerous, and struck by the city as a colonia. Of the imperial copper coins of Byblus, one of Macrinus may be noticed, as bearing for its reverse-type the representation in perspective of a temple of curious construction, one of the many illustrations of architecture which this class affords. The silver pieces of Sidon are tetradrachms and didrachms of the Ptolemaic talent. The obverse bears the bust of the city, personified as a female veiled and turreted; and the reverse the eagle of the Ptolemies. The earlier of the coins are of good work on the obverse, although not of a high style. The autonomous copper coins have interesting types, among which we may notice Europa carried by the bull; a device mentioned by Lucian as borne on the money of this place. Some of the coins of this class have Phœnician as well as Greek inscriptions. The imperial copper does not form a long series: it first bears Greek inscriptions, but afterwards Latin as a colonia. The coins are dated by two eras, the first supposed to be that of the Seleucidæ, the second that of the autonomy of the town. The autonomous and imperial coins of Tripolis must be mentioned. Next in order stands the series of Tyre. This comprises many silver autonomous coins, the principal pieces being tetradrachms of the Ptolemaic talent. The obverse-type is a laureate and beardless head, seemingly of Hercules; and the reverse-type a Ptolemaic eagle, behind which is a palm-branch. The head may perhaps be assimilated to the portrait of a Ptolemy. None of the pieces are fine, but a few have some merit. There are also autonomous copper coins, as well as imperial pieces of the Roman colonia. The dates are in two eras, as at Sidon, supposed to be that of the Seleucidæ, and that of the autonomy of Tyre. There can be no doubt that some of the early so-called Persian coins must have been struck at Tyre. These may be distinguished by future investigations. The insular city of Aradus is represented by an interesting series. This probably commences with Phœnician pieces issued under the Persian rule, but such have not been positively attributed. The most important Greek coins are tetradrachms, having for their obverse-type the turreted and veiled bust of the city personified, but of Phœnician weight, unlike the similar coins of Syrian cities. They are of poor work, and bear dates in the Era of the Seleucidæ. Drachms, which appear from their style to be somewhat earlier, have on the obverse a bee, and on the reverse a stag, behind which is a palm-tree—types of Ephesus. These must be of the Attic standard, somewhat depreciated, unless they are of a very heavy Phœnician weight. There are copper coins of Phœnicia, having Phœnician letters only, and at least generally subsequent in time to the Persian domination. These require careful study in order to their satisfactory classification to the cities which issued them.

Greek Coins.

In Galilee there a few imperial copper pieces of Ptolemais, Sepphoris, and Tiberias; and in Samaria, some of Cæsarea, and a greater number of Neapolis. In Judæa there are no autonomous coins of Jerusalem, although the pieces supposed to have been issued by Simon the Maccabee were no doubt there struck. There are, indeed, some imperial copper coins of the colonia Ælia Capitolina, founded on the ruins of Jerusalem by Hadrian. It may also be mentioned that there are a few copper pieces, both autonomous and imperial, of Ascalon and Gaza. By far the most interesting coins are, however, those with Hebrew inscriptions, which are usually assigned, and we believe justly, to Simon the Maccabee. These are shekels and half-shekels, respectively equivalent to tetradrachms and didrachms of the Egyptian talent.[1] The shekels bear on the obverse the pot of manna, with the inscription, שקל ישראל ("The shekel of Israel"), and the letter ש, for שנה ("year"), followed by a letter indicating the date; and on the reverse, Aaron's rod that budded, with the inscription ירושלים הקדושה ("Jerusalem the Holy"). The half-shekels have the same types, but their reverse inscription is חצי השקל ("Half-shekel"). The dates which occur on either shekels or half-shekels are those of the years 1, 2, 3, and 4. The letters are in what is called the coin character, an old form of Hebrew. The weight of the coins shows that they must have been struck under either the Ptolemies or the Seleucidæ; and in the latter case they may be compared to the pieces of Phœnician cities following the standard of the kings of Egypt, although issued under the authority of the Syrian kings. During the period thus indicated we find that the right of coining money with his own stamp was granted to Simon the Maccabee by Antiochus VII.;[2] and there would be no question that this was the date of these pieces, were it not that it is said that the Jews adopted as an era the previous establishing of the freedom of the country by the treaty of Simon and Demetrius II., between two and four years earlier.[3] This difficulty may, however, be explained, if we suppose either that Antiochus merely con-

Judæa, &c.

[1] M. Ch. Lenormant finds fault with Josephus for saying that the shekel is equal to four Attic drachms (ὁ δὲ σίκλος νόμισμα Ἑβραίων ὤν, Ἀττικὰς δέχεται δράχμας τέσσαρας, *Ant. Jud.* iii. 8, 2). He argues, that the weight of the so-called Maccabean shekel being that of a Phœnician tetradrachm is much below that of an Attic tetradrachm (*Revue Numismatique*, Fr., 1845, pp. 180, 181). It is perfectly true that there was this difference between the Maccabean shekel and the contemporary Attic tetradrachm; but Josephus must be understood to speak of the Attic tetradrachm or drachm of his own time. By gradual depreciation the Attic drachm had come to be equivalent, under Augustus, to the Roman denarius, so that the two coins were considered thenceforward identical; and thus pieces struck at Ephesus a little earlier than the time of Josephus which have the weight of a denarius and of two denarii, bear respectively the inscriptions ΔΡΑΧΜΗ and ΔΙΔΡΑΧΜΟΝ. At the same period the denarius was almost exactly equal to the quarter of a Maccabean shekel. There is no question, then, that Josephus was right in saying that the shekel was equal to four Attic drachms, meaning the current Attic drachms, and not the older pieces of the full weight. It may be noticed that the later coins of the same kind subsequently mentioned are shekels of the old weight, and their quarters struck on Roman denarii. There is no reason, therefore, to suppose that the Jewish coins show a depreciation like that of those with which Josephus compares them.

[2] 1 Macc. xv. 6.

[3] Id. xiii. 42.

Greek Coins.

firmed privileges before granted by his brother,[1] or else that he gave his sanction to the Jewish money already issued. There are also copper coins of subsequent princes of Judæa, ending under Agrippa II. Their inscriptions are at first in Hebrew and in Greek, but afterwards in the latter language only. Of a later period there are autonomous silver and copper coins, with Hebrew inscriptions, like those of the coins assigned to Simon, but with a difference in the form of the characters. There are shekels of this class, which, notwithstanding their strange fabric, appear to be genuine. The smaller silver coins are usually or always re-struck Roman denarii, and cannot be doubted. The proper name that occurs on both, as well as on the copper, is שמעון. There is no doubt that these pieces were issued by Barchochebas, who raised the Jews in the time of Hadrian; but it is doubtful whether the name Simeon refers to him or to Simon the Maccabee. There is also a class of uncertain imperial copper coins of Judæa, which may perhaps have been struck at Jerusalem.

Arabia, &c.

Of Roman Arabia there are imperial copper coins of the country generally, as well as of the cities Bostra and Petra. In Mesopotamia the autonomous coinage is unimportant; but the imperial copper money of Carrhæ, Edessa, Nisibis, and Rhesæna is worthy of notice. There are also coins of the kings of Edessa, generally bearing the name of the contemporary Roman emperor or empress; a few are denarii, but the greater number are copper pieces. Of Assyria, there are autonomous copper coins of Atusia ad Caprum, and imperial pieces in the same metal of the famous Nineveh as a Roman colonia, with the name NINIVA CLAVDIOPOLIS. The known coinage of Babylonia is very scanty. It is possible that among the earliest money of what is termed the Persian series there may be some of the last days of the old kingdom of Babylon. There are copper coins of Molon and Timarchus, kings of Babylon, of a much later period. The former was a satrap of Media who rebelled against Antiochus III., B.C. 223, and was defeated and slew himself B.C. 220. His money shows that he took the title of king.

Egypt.

The coins of ancient Africa, including Egypt, are far less numerous than those of the other two continents. The most important series is that of Egypt. There are no coins that can be assigned to the period anterior to the conquest by Cambyses, nor do the Egyptian monuments bear any representations of money; but we learn from them that gold and silver were kept in rings, and weighed when their value was to be ascertained. From the time of Cambyses, Persian coins must have been in circulation in Egypt; and indeed Herodotus tells us that Aryandes, governor under this king and Darius Hystaspis, was put to death by the latter for issuing silver money. In the Persian series there are some pieces in a kind of spurious Egyptian style, which are not improbably of Aryandes. The certain coinage of the country commences with that of the first Ptolemy, bearing his name. There can be little doubt that some of the money of Alexander the Great was struck in Egypt; and it seems most probable that Ptolemy issued coins first for Philip Arrhidæus and then for Alexander Ægus, the titular kings in whose names he governed in the earlier part of his rule. The proper Ptolemaic coinage is in the three metals. The gold and silver pieces are adjusted to the Ptolemaic or Alexandrian talent, but there are examples of Attic weight in one reign. The principal denomination of gold money is the octodrachm, but the pentadrachm and tetradrachm are also found. In silver the chief coin is the tetradrachm, but there are also decadrachms. The copper coins are adjusted to an Egyptian talent, distinct from that of the other money, and probably representing the old native system. The gold and silver pieces of the earlier Ptolemies are comparatively numerous, and are chiefly of the heavier denominations. Their art is superior to that of the money of the later princes, of whom there is scarcely anything but copper. The art of the first period is fair, the portraits being usually good in style, and sometimes, in the case of the queens, excellent. The designs, except the portraits, are uninteresting, and of no great variety. The whole series requires a more careful examination than it has yet received in order to its accurate classification. It is especially desirable that the indications of places of mintage offered by the coins should be considered. At present scarcely anything can be said, but that it is probable that many were struck in cities of Cyprus and Phœnicia, although some must have been issued in Egypt, particularly after the loss of foreign dominion. The chief coins of the first Ptolemy are pentadrachms in gold and tetradrachms in silver. In both the king's bust occupies the obverse, and an eagle on a thunderbolt, the reverse. The portrait is good. The tetradrachms, which are very numerous, bear dates. Some of the copper coins of this reign have on the one side the bust of the king, and on the other that of Berenice. To the time of Ptolemy Philadelphus we must assign gold octodrachms and tetradrachms, with, on the one side, the portraits of Ptolemy I. and Berenice, and on the other, those of Ptolemy II. and Arsinoë. It is probable that most of the silver coins of the second Ptolemy bear his father's portrait. Of his queen, Arsinoë, there is a fine series of both gold and silver pieces. The gold coins known are principally octodrachms, and the silver are all decadrachms. The obverse-type in both cases is the head of the queen, with a tiara and veil, a good design, but not in the best style; and the reverse-type is a double cornucopiæ. Of Ptolemy Euergetes there are fine gold octodrachms, having on the obverse the king's bust, wearing a radiate diadem and an embroidered chlamys, and with a sceptre-like trident; and on the reverse a radiate cornucopiæ. The portrait is in a good style. Of Berenice there are gold and silver coins, some of which have Attic weight. The portrait is generally of good style, and in one case very beautiful and somewhat different from the common one, though its attribution is confirmed by the fame of this Berenice's beauty. Tetradrachms, in silver, of Ptolemy Philopator are known; and octodrachms, in gold, of Arsinoë. The obverse in both cases is occupied by a portrait, that of the queen being of great beauty. Of Ptolemy Epiphanes there are gold octodrachms and silver tetradrachms, both bearing his portrait, well executed. Tetradrachms of Ptolemy Philometor likewise occur. The coins of the later Ptolemies are not yet satisfactorily classed. They are, as already noticed, principally of copper. There are silver coins, didrachms and drachms, bearing on the obverse the bust of a young man in the character of Bacchus, which are doubtless of Ptolemy Neus Dionysus, or Auletes. The Egyptian coinage of the famous Cleopatra seems to have been only of copper pieces. They bear her bust on the obverse; the face is intelligent, but not beautiful. Her head, with that of Mark Antony, occurs on silver coins of the Roman province Asia. The greatest portion of the Ptolemaic copper money cannot be exactly classed, since it bears no indication of the reigns during which it was issued; so that difference of style is the main guide. The common types are, for the obverse the bearded head of Jupiter Ammon, and for the reverse an eagle on a thunderbolt. Some of these copper coins are very large and heavy.

Greek Coins.

Of the Roman period, the imperial series of Alexandria, whether we consider its extent or the interest of its types, is the most remarkable in its class, and deserving of far more study than it has received. It commences under Augustus, and terminates with Constantius I. and Galerius Maximianus; thus lasting longer than the Greek imperial money elsewhere. In the earlier part of the period there are potin coins, representing silver money, and most probably meant for tetradrachms of the Ptolemaic standard; but the common metal is copper, at first struck in several sizes, including some that are large. The types are very various; they are Græco-Roman, and even purely Roman (though not technically so), Greek, Græco-Egyptian, and Egyptian. The Egyptian types are very interesting, and form a series standing by itself. The coins of this last kind begin to deserve especial attention under Domitian; and those of Trajan, Hadrian, and Antoninus Pius are numerous and interesting. One of the last emperor, dated in his sixth year, is particularly important, as commemorating the commencement of a Sothic Cycle, A.D. 139:[2] the type is a crane, the Egyptian ben-nu or phœnix,[3] with a kind of radiate nimbus round its head, and the inscription is AIΩN. The coins of the subsequent emperors are less important. About the time of Claudius Gothicus, and thenceforward, there seems to be but one size of coin, the material of which is copper, generally or always washed with silver. The coins of the Nomes of Egypt form a remarkable class. They belong to a short period, the earliest being dated in the eleventh year of Trajan, and the latest in the eighth year of Antoninus Pius. Their metal is copper, and they are of different sizes. There can be no doubt that they were struck at the metropolis of each Nome. The types relate to the local worship, and thus illustrate the Egyptian religion. The inscriptions are the names of the Nomes. There is an exceptional coin of the town of Pelusium. (The work of Zoëga affords the best account of the coinage of Egypt under the Romans.[4])

Libya, &c.

Passing beyond Egypt, we may notice that there are a few autonomous coins of Libya, and, in Marmarica, of Petra. In the Cyrenaica there is an interesting series of Cyrene. The gold coins are numerous, and of the time of good art, some showing a decline. The heaviest pieces are Attic staters or didrachms, bearing on one side a victorious quadriga, in the earlier examples driven by what seems to be a male charioteer, in the later by Victory. Coins of half the weight of these, or gold drachms, have on the obverse a horseman, and on the reverse the sacred silphium plant. On smaller pieces the head of Jupiter Ammon occurs, both bearded and beardless. The weight of the silver coins is at first Attic, but it becomes very light, the tetradrachms being reduced to very nearly an equality with tridrachms, and thus considerably below the Ptolemaic tetradrachms.

[1] Comp. Macc. xv. 5. [2] *Horæ Ag.*, p. 32. [3] Id., p. 40, *et seq.* [4] *Numi Ægyptii Imperatorii* (Gr. Zoëga), 4to, Rom. 1787.

Roman Coins.

The cause of the change may have been the influence of Rhodian and other light coins, but the occasion is not known; in time it was probably anterior to the rule of Magas. There are didrachms, besides the tetradrachms. The art of the silver coins is sometimes fair, although never very fine. The usual types are, for the obverse the bearded or beardless head of Ammon, the former sometimes crowned with silphium, and for the reverse the silphium plant. Some of the copper pieces are relatively of a fair style. Of the Cyrenaica generally there are Greek and Roman coins, the latter issued by Roman officials. Of the town of Barce there are both gold and silver pieces, the former not being common. The silver series commences with somewhat archaic coins. The standard is Attic, with the same change as at Cyrene. The types are, for the obverse the silphium, and for the reverse the head of Ammon; designs which in some of the later coins change places. In Syrtica the autonomous Roman coins of the colonia Leptis Magna, and in Zeugitana the money of Carthage, are deserving of notice. In speaking of the Siculo-Punic coinage, we have already had occasion to treat of the money of the Carthaginians issued in Sicily. Their African coinage has the same chief types, the head of Proserpine, and the horse or horse's head and palm-tree. It follows the Phœnician talent, and the dodecadrachm and decadrachm are known, besides tetradrachms and smaller pieces. Some copper coins are known of the city of the Roman period with Latin inscriptions. There are a few imperial pieces of towns of Mauritania, as well as an interesting series of the kings of Numidia and Mauritania. There are silver coins of Bocchus, silver and copper of Juba I. and Juba II., as well as the latter with Cleopatra; copper of Cleopatra alone; and silver and copper of Ptolemy. The silver pieces of this series are probably for the most part low denarii. On the whole, the coinage of Africa beyond Egypt is poor and of small interest.

Sect. IV.—ROMAN COINS.

The ancient Roman coinage appears to have commenced late in the fourth, or early in the third century B.C., and to have continued without interruption until the fall of the Western Empire, A.D. 476. It will be necessary here to give a sketch of the characteristics of its great classes. The earliest Roman coins are of gold, silver, and copper, of Greek fabric and with Greek types, but Latin inscriptions. Their art shows that they date from about the time of Pyrrhus to near the close of the third century B.C. There can be no doubt that they were issued by Campanian cities subject to the commonwealth. After a time the Romans had a proper coinage of Roman or Etruscan fabric, and with Roman types as well as Latin inscriptions. With this class the proper Roman coinage commences. The period of these coins is different with those of each metal. The silver and copper money probably began about the same time, near the close of the third century B.C.; and terminated, in the case of the former about B.C. 80, in that of the latter somewhat earlier. The late silver coins are of Campania only; and the same is the case with all the gold pieces, which were most probably struck between B.C. 90 and 80. It will be seen that the later coins of this class considerably overlap in time the earlier of the next class, but their types forbid our altering the arrangement. The copper coins, commonly called *æs grave*, are the most important. They are of heavy weight and coarse fabric, bearing rude types, the most common of which are, for the obverse the head of Janus bifrons, and for the reverse the prow of a galley. The silver coins usually have as their obverse-type the head of Minerva, and the gold ones, that of Janus. This class was succeeded, though in an irregular manner, by what is called the family or consular series, the latter of which appellations is incorrect. Its coins are of the three metals, and with Roman types and Latin inscriptions. They were struck at Rome from B.C. *cir.* 170 to the time of Augustus, by individuals to whom the state allowed the right of coinage, whose names they bear, and they are therefore classed according to the Roman families. The gold and silver family coins usually have on the obverse the head of a divinity, or of a personification, or of a traditional or historical personage; and, on the reverse a mythological, symbolical, traditional, or historical subject. They are generally of better art than the æs grave, which the copper coins, on the contrary, follow in art as well as in types. The imperial coinage may be considered to commence with that of Julius Cæsar, although the family series does not then terminate. It is of two classes; that of the pagan emperors, and that of the Christian emperors. The former class ends under the reign of Constantine, when he changed the coinage. The coins are of gold, silver, and copper; the last including brass. Their designs from the time of Augustus to the decline of the empire show a fair style of art, and display great mechanical skill. They most nearly resemble modern coins, particularly in form and thickness, but their designs are generally in higher relief. The obverses bear the portrait of an emperor or empress, or of a Cæsar; and the reverses, historical, mythological, or symbolical types. Towards the latter part of its period the coins become thinner in form and of much lower art and execution. The second class of imperial money, that issued by Constantine for the greater part of his reign, and by his successors to the fall of the Western Empire, is of gold, silver, and copper, and is mainly to be distinguished from the preceding one by the absence of pagan types, and by a further decline in its art. It is important to distinguish the five great divisions of Roman money which we have described, and which may be called the Greek coinage of the commonwealth, the early Roman coinage, the family coinage, that of the pagan, and that of the Christian emperors.

Classes.

Roman Coins.

In seeking the motives which influenced the choice of the types of the proper Roman coinage, we must not imagine too close an analogy with the case of Greek money. The idea of the first coinage, that of the Campanian cities, which was not properly Roman, was to adopt subjects connected with religion. This feeling was maintained, though it seems somewhat ignorantly, in the æs grave. Under the empire, however, the sovereign became the source of the chief types, although the religious motive was, perhaps for a reason of policy, never wholly abandoned. An inscription of the time of Diocletian, SACRA MONETA AVGG NN (*Augustorum nostrorum*), well expresses this idea; the coinage personified by the goddess is still sacred, but yet it is the emperors'. The proper Roman coinage, if separated according to its types, falls into four classes, the æs grave, the family silver and gold (for the copper maintained the old types), the pagan imperial, and the Christian imperial. The designs of the first are, like those of the early Greek coins, sacred distinctive symbols, though, as already noticed, probably not always understood by those who used them. The types of the family silver and gold coins are somewhat different from those of any class of money which we have already noticed. The primary religious motive is indeed to be clearly traced in them; but their having been selected to distinguish families, instead of towns or tribes, gives them a peculiar character. The following are the principal classes to which these types may be reduced:—

Devices and inscriptions.

1. Head or figure of a divinity worshipped at Rome; as head of Jupiter (fam. Petillia), figures of the Dioscuri (Junia), or of a divinity worshipped by the family or individual striking the coin, as head of Neptune (Pompeia, coin of Sextus Pompeius).

2. Sacred natural or artificial object; as pontifical implements (Antonia).—This class is not a very large one, and sacred animals rarely occur.

3. Head or figure of a personification of a country or town; as heads of Hispania (Carisia), Roma (Julia), Alexandria Ægypti (Æmilia).

4. Head or figure of an allegorical personage; as heads of Pavor (Hostilia), Pallor (id.), Honos and Virtus (Fufia, Mucia).

5. Fabulous monster; as Scylla (Pompeia).

6. Head or figure of an ancestral personage; as heads of Numa (Calpurnia), Ancus Marcius (Marcia).

7. Events connected with ancestors; as figure of Marcus Lepidus, as TVTOR REG [is], crowning Ptolemy Epiphanes (Æmilia).

8. Places connected with historical exploits, and of a votive character; as Pharos of Messana (Pompeia, of Sextus, probably commemorating the sea-fight off Messana, B.C. 38).

9. Symbolical representations commemorating contemporary events, as a general welcomed on landing by a country or city (Minatia).

10. Heads of living personages exercising dictatorial power, or in very high authority; as head of Sylla (Cornelia).

11. Representations connected with military matters; as legionary standards (Antonia)

Besides the principal designs, there are symbols and numerals, generally to be regarded as having been indicative of successive issues from the mint. The inscriptions are usually, on the obverse the name of the personage represented, with, in the field, X for denarius, and the like; and on the reverse the name of the person who issued the coin: the latter sometimes occurs on the obverse. The inscriptions are in the nominative,

Roman Coins.

The series of Roman imperial coins of the pagan emperors (commencing with Julius Cæsar, and terminating with the adoption of Christian types by Constantine the Great) bears devices of the same general character as those of the family money, but with a far stronger relation to living persons and events than to mythology. The obverse-type of this period is the portrait of an imperial personage, an emperor, an empress, or a Cæsar; and the reverse bears some subject directly or tropically connected with their actions. Under Julius and Augustus moneyers of powerful families shared the right of issuing coins with the head of the state; their money is like that of the family series, to which it should be assigned, but it generally bears on the obverse the head of the emperor, if we may include Julius with Augustus under that name. In the reign of Augustus, however, this privilege ceased; and the emperor struck the gold and silver money, while the copper was issued by the senate, and therefore always bears the characters S. C., for *Senatûs consultu*. Without repeating what we have said of the types of the Roman family coins, we may mention the principal kinds of types of the imperial coins. Those of the obverses vary only in the treatment of the head or bust of the imperial personage. Those of the reverses are commonly mythological, representing divinities; or allegorical, representing personifications; or historical, representing, either directly or tropically, acts done or works executed by the reigning emperor. Thus the coins of Hadrian, besides bearing the figures of the principal Roman divinities and personifications, commemorate, by allegorical representations of countries or cities, the emperor's progresses, and, by actual representations, his architectural works. The inscriptions of the coins of the pagan empire are either simply descriptive, such as the emperor's names and titles in the nominative, on the obverse, or partly on the obverse and partly on the reverse, and the name of the subject on the reverse; or else they are dedicatory, the imperial names and titles being given on the obverse in the dative, and the name of the type on the reverse. On the latter there is sometimes a directly dedicatory inscription to the emperor. The inscriptions of the earlier imperial coins, from Tiberius to Alexander Severus, have generally a chronological character, usually giving the current consulship of the emperor, or his last consulship, if he did not at the time hold that office, as well as the year of his tribunitian power. In the latter part of the third century an indication of the towns at which the coins were struck commences, usually occupying the exergue of their reverses. There are also sometimes characters or signs in the field. The geographical indications are not completely understood, but it is probable that they generally mark not only the place of striking, but each fresh issue of the same type.

The coins of the Christian empire differ from those of the pagan empire mainly in the character of their reverse-types. These are generally allegorical and free from pagan intention, though not from pagan influence, as in the cases of the common types of Victory inscribing the emperor's *vota* upon a shield, or in later times holding a long cross, and of seated Rome. Purely Christian types are less common: the most remarkable is that of the monogram of the name of our Saviour, formed of X and P, the latter letter being placed vertically across the former. The inscription HOC SIGNO VICTOR ERIS, on coins dating not many years after the victory of Constantine over Licinius, must also be noticed. The inscriptions generally show the same change as the types. There are many varieties, but very few absolutely different types and inscriptions.

Art.

Roman coins, if classed according to their art, fall into three main divisions,—that of rude and slightly progressive art, that of the best art, and that of declining art. The period of the first class commences with the issue of the æs grave, about the latter part of the third century B.C., and lasts to the accession of Augustus; that of the second comprises the reigns of that emperor and his successors, as far as the death of Commodus; and that of the third extends from this time to the close of the empire. The case is a very different one from that of the Greek coinage, for the improvement of art in the time before Augustus is in general very slow, and the great advance made in his money is owing to a better system, and the employment of Greek artists. The decline, which sensibly commences in the reign of Commodus, although his coins are generally of good style, is not very rapid, and receives occasional checks, until, at the time of Diocletian, there is a sensible improvement, which, however, is more evident in the execution of the coins than in their designs. The money of Constantine the Great is perhaps the best of this time; under his sons decline has again begun, and it steadily, though still slowly, continues until the close of the empire.

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We shall here speak only of the best art of Roman coins, as in the case of the art of Greek coins, and for stronger reasons. The art of Roman coins is not steadily progressive from internal vigour, and in its time of excellence is far more foreign than native in character. It is, however, well worthy of study, in this period, for its intrinsic merit, for its illustration of contemporary sculpture, and on account of its influence on mediæval and modern numismatic art. The Roman coins were designed under the revival of Greek art, during the empire, by the Græco-Roman school. The Romans had properly no art of their own. Their greatest temples, and the statues of their gods, were essentially copies or imitations by Greeks of Greek works, except, in the case of the statues, some few Greek originals of an earlier time. Both differed from the best Greek works in a want of simplicity and purity of design and execution, and the statues show a tendency to pictorial and dramatic rather than ideal treatment. The portrait statues and busts are most characteristic of this style. With an evident faithfulness, they usually show a deficiency of grandeur, and occasionally some mannerism. Perhaps the most excellent example of this class is the bust commonly called that of Clytie, in the British Museum, which is undoubtedly a portrait of the Græco-Roman school. The best Roman coins approach most nearly to the excellence of this very beautiful sculpture. As simple medallic portraits, they are indeed scarcely surpassed, except by the still more pictorial Italian medals of the fifteenth and sixteenth centuries; but they never rise to the simple grandeur of the few good Greek portraits that occur on coins. The difference is this: the Greek sculptor seized the highest expression of the face he would represent, and produced an ideal portrait; while the Græco-Roman copied the usual expression, and produced nothing beyond a faithful portrait. The finest examples of Græco-Roman art on coins are the portrait of Livia as Pietas, Justitia, and Salus, and that of the elder Agrippina, on copper coins; and those of the elder and younger Faustinas, in the gold series. The medallions and copper coins of Trajan, Hadrian, Antoninus Pius, and Commodus, are on both sides of excellent design and beautiful workmanship. For portraits, none of the period are more interesting than the coins of Nero, the growth of whose bad passions may be traced in the increasing brutality of his features and their expression. In the case of other emperors, the portraits are either always the same, or taken at two ages. The whole series from Augustus to Commodus is well worthy careful examination, especially as affording some of the best specimens of the work of an important school of ancient art. This Græco-Roman school is seen to far more advantage in these works than in its attempts—and these but imitative—at high sculpture, in which, through an inadequate ideal, it failed to produce anything pure, elevated, and simple. Let any one who would see how far it fell short compare the Venus of the Capitol with the Venus of Melos.

Systems of coinage.

We have already had occasion to speak of the mode in which Roman coins were struck, and we may now pass on to consider the denominations of the coinage at different times. The subject is one of extreme difficulty, from the disagreement of the evidence of ancient writers with that of the coins themselves, and the obscurity of the indications offered by the latter. It was believed, until lately, that some existing Roman coins were as early as the period of the kings, from the statement of Pliny, that Servius Tullius first struck copper money, and from the ancient appearance of the specimens in question. Any such theory is, however, wholly untenable. The earliest Roman coins, as we have already mentioned, were of Greek fabric, and issued by Campanian cities. The gold and silver appear to follow the Greek system of the Attic talent, while the copper are on the Italian system. The denominations of the second class are, in gold, the aureus and half-aureus; in silver, the denarius, and its half, the quinarius; and in copper, the as, with certain of its divisions. The denominations of the third class, or family series, are in general the same as those of the preceding class, with, in the copper, a depreciation of weight. The denominations of the fourth class—that of the pagan empire—are the same, though again of constantly decreasing weight. The fifth class, comprising the money of the Chris-

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tian emperors from Constantine's change in the coinage until the fall of the Empire of the West, has a different system of denominations.

Gold coins.

We may now notice the money of each metal in particular, from the commencement of a Roman system with what we have called the second class of Roman coins. Pliny states that the first aurei were struck, forty-five from the pound of gold, B.C. 207; a date which well agrees with what must be that of the oldest silver coins of this class. The gold coins of the same class seem to have been on this standard, for they weigh a little more than a hundred grains, which would indicate that about forty-five were struck from the pound. There is also in this series a half-aureus (a coin of which we do not know the ancient appellation) of this series. The aurei of the next class—the family series—fluctuate in weight. The earliest are somewhat heavier than those of the preceding class; those of the time of Sylla are very much heavier, having been struck thirty to the pound; while those of Pompey are forty to the pound, a reduction mentioned by Pliny. There are no half-aurei of the family series known, but they are found of the reign of Augustus. From the time of Augustus the weight of the aureus was gradually lowered, until Nero fixed the number to be struck from the pound of gold at forty-five, making a corresponding change in the silver money. Caracalla, in A.D. 215, further reduced the aureus by striking fifty from the pound; and many of his successors issued gold coins that were much lighter than the weight thus fixed. Under Constantine the Great a new coin was substituted for the aureus, called *solidus*, or *νόμισμα*, of which seventy-two were coined from the pound. This continued to be the principal Roman gold coin, and to maintain its full weight, to the fall of the Empire of the West, and, indeed, with little change of weight, though latterly much alloyed, until the end of the Byzantine Empire. The divisions of the solidus were the half and third, commonly, but without authority, and, in the case of the latter, incorrectly, called the *semissis* and *tremissis*.

Silver coins.

The principal silver coin of the commonwealth was the denarius, of which there were twenty-five to the aureus. Pliny makes the first denarii to have been struck as early as B.C. 269; but there are no specimens that we can ascribe to an earlier period than the date he assigns to the first aureus—B.C. 207. It may be remarked, however, that since the denarius is derived from the Attic drachm, the Campanian Attic drachms of Greek types might have been considered by Pliny as the first denarii; although the principal gold coins of the same class could not be called the first aurei. In this case the date would perfectly apply. The denarius received its name from its being at first equivalent to ten asses. It had two divisions in silver—its half, the quinarius; and its quarter, the sestertius: the quinarius, when bearing the figure of Victory on its reverse, was termed *victoriatus*. Smaller silver coins are mentioned by ancient writers as current under the commonwealth, but no examples of them have been recognised. There are quinarii of the second class of Roman coins, that to which the earliest denarii belong. The victoriati are said to have been struck by a Clodian law (Plin. *N.H.*, lib. xxxiii., § 13), but it has not been ascertained when this law was enacted. The sestertii are all, as far as we know, of a later time. It is said that at first a hundred denarii were struck from the pound of silver; and accordingly we find that the oldest weigh from 50 grains to above 60. In the time of Augustus, however, eighty-four denarii were struck from the pound. When Nero lowered the weight of the aureus, he proportionately reduced the denarius, coining ninety-six from the pound. In subsequent reigns the proportion of alloy was constantly increased, until, in the time of Severus, it was one-half of the weight of the coin. Caracalla, in A.D. 215, legalized a considerable proportion of alloy in the denarius, and issued a new coin, called after him the *Argenteus Antoninianus*, of which sixty were struck from the pound—a coin which not very long afterwards supplanted the denarius. The argenteus was considerably alloyed, and later emperors made it baser by degrees, until at length it was a copper coin washed with silver, and even tin. The types of obverse introduced by Caracalla were always maintained; they represent the bust of the emperor with a radiate crown, as Phœbus, and that of the empress resting on a crescent, as Diana. Diocletian again issued coins of good silver of two denominations, one of which appears to represent the argenteus, though without its types, and the other the denarius. Constantine the Great added other denominations, all which have not been satisfactorily identified among his coins. The principal silver coin of his time was the cententionalis, weighing a little less than 50 grains, which was probably first issued by Diocletian. This system was followed to the end of the Empire of the West, although but two denominations were usually struck, which seem to be the cententionalis and a piece of half its value.

Roman Coins.

Copper coins.

The earliest proper Roman copper coinage has been generally supposed to be as ancient as the time of the kings. The principles of just criticism forbid us, however, from carrying any of these coins to a remoter period than the latest part of the third century before the Christian Era. The as, which was the principal copper coin, is said to have been first coined of the weight of a pound; and therefore when the weight of the denomination had been lowered by authority, these oldest asses were called *librales*. For the same reason, the whole class of heavy copper coins received the name of *æs grave* when there was a lighter currency. It is not clear whether this appellation anciently included all the copper money of this kind, whether of Rome or of Etruscan cities, heavier than that bearing the names of Roman families; but this was probably the case. The as, like the libra, contained twelve *unciæ*, or ounces; and the divisions which were commonly struck were the *semis* or *semissis*, its half; the *triens*, or third; the *quadrans*, or quarter; the *sextans*, or sixth; and the *uncia*, or twelfth. The other divisions of the as which have been noticed are, according to M. Cohen, the *quincunx*, or five ounces, without Rome; and the *bes* or *bessis*, or eight ounces; and *dodrans*, or nine ounces; which last two have been alone found among the coins of the family Cassia.[1] The Roman pound has been estimated by Böckh at 5053 grains,[2] but no as has been found, as far as we know, nearly equal to this estimate. There are, however, specimens which are of not much less weight; and if we make allowance for waste by rusting and for irregularity of striking, which is especially great in almost all copper coinage, and generally below the standard, we may consider they fairly represent the *asses librales*. An examination of the divisions of the as leads to the same result. There are also larger pieces of metal of greater weight than the as, and of an oblong form, bearing on one side the figure of a bull, of which some true specimens remain, although most of those which are in cabinets are forgeries. They are of the period of the æs grave, and might be supposed to represent the sum of three asses (called *tressis*), or ten asses (called *decussis*), according to when they were struck; but it is doubtful if they are more than pieces of metal containing a number of pounds without fractions, like the so-called Celtic ring-money. While the earliest asses and their divisions are of nearly full weight, we find the later ones are much lighter. During the period of what we have called the second class of Roman coins, which commences with the issue of a proper Roman coinage, the as appears, from existing specimens, to have gradually fallen to the sixth part of its original weight by a degradation that was probably on the whole regular. During the next period—that of the family coins—the asses seem to be only of the weight of either two ounces or a single ounce. Under Julius Cæsar the as weighs not quite half an ounce; and we first observe two new copper coins—the *sestertius*, and its half, the *dupondius*. At this time the number of asses to the denarius had already been increased to sixteen; so that the sestertius, which was the quarter of the denarius, contained four asses. The sestertius, however, and the dupondius, were struck of fine yellow brass (*orichalcum*), while the as was of copper. Instead, therefore, of weighing two ounces and one ounce respectively, they weighed one ounce and half an ounce; while the as weighed nearly half an ounce. The reason that the as is defective, rather than the dupondius excessive, probably is, that its weight was that to which the coin had already fallen, and that it was considered better to make the new piece of an exact weight than slightly to raise the old one. The dupondius and as, being nearly of the same weight, and having the same types, are in general only to be distinguished by the difference of metal, and sometimes the more careful work of the former. The rust produced by the chemical action of different soils often hides the colour of the metal, and so takes away the principal means of discrimination; yet the two may usually be distinguished, at least as late as the time of the Antonines, particularly if one is careful to compare them with the sestertii, to which the dupondii always have a nearer resemblance than have the asses. Divisions of the as are very uncommon under the empire. Those which exist are of the period extending from the accession of Augustus to that of Gallienus. From that time it is doubtful if any were coined. The very small pieces issued considerably later do not seem to have corresponded to any one of the old coins. The copper coinage, like the silver and gold, suffered considerable changes. Alexander Severus, or, as he is called on the coins, Severus Alexander, reduced the sestertius and dupondius to two-thirds of their former weight. A few years afterwards a larger coin or denarius of brass, equal to four sestertii, was issued, called the *Philippus æreus*, from the Emperor Philip, who seems to have first struck it. In the time of Gallienus the sestertii and dupondii cease altogether, at least as a regular series, and the principal coin seems to

[1] *Monnaies de la Rép. Rom.*, p. vii.

[2] *Metr. Untersuch.*, p. 165.

Roman Coins.

be the as, now a small piece coined of brass, and some larger pieces, generally Philippi ærei. In the reign of Diocletian a new coin of copper, frequently plated (the *follis* or *terurtianus*), was introduced; and the Philippus æreus appears to have been abandoned at the same time. The smaller coin, which is also of copper, appears to be the *assarion*. Constantine the Great changed the copper coinage; but he seems to have taken the money of Diocletian as the basis of his coinage. His copper money consists of two principal denominations, which differ only from those of Diocletian in being somewhat lighter, and the half of the smaller coin. Thenceforward, to the end of the empire, there was no very important change, except that the largest coin, the follis, fell into disuse after the time of Honorius, and that there was a constant diminution in the weight of the others. The common division of the Roman copper money, according to its size, is into first brass, second or middle brass, and third brass. The first class includes the sestertii, the second the dupondii and earlier asses, the third the later asses and all smaller coins. It is not necessary to show the faults of an arrangement that is so thoroughly unscientific in character; but we must protest against its use in the arrangement of cabinets, and the consequent injury to the real progress of numismatic inquiry.

Medallions and tickets.

In addition to the Roman coins, there are certain pieces which cannot be properly considered to have been money. These may be classed as medallions and tickets. The medallions are of gold, silver, and brass or copper, and usually larger than the largest coin of the time of their metal. They are generally, if not always, of the weight of a number of coins without fraction; but they are not therefore to be considered as part of the currency. The gold medallions commence under Constantine the Great, and continue to the end of the empire; the silver probably commence under Gallienus, and last to the same time; and the copper commence with Augustus, and continue at least to the reign of Alexander Severus. The types resemble those of the coins, but have an especial reference, in the case of the copper pieces, on account of their having been set in the standards, to military matters. The work of all is usually finer than that of the current money. Of the tickets, the most interesting are the *contorniates*, which were probably struck between the time of Constantine the Great and the fall of the empire, and were connected with the games.

(The most valuable treatise on the entire class of Roman coins is the part of Eckhel's *Doctrina Numorum Veterum* which relates to it. Except with reference to the family series, no great advance has been made since its publication; and on the whole it is both the most complete and the most learned account of Roman money. Mionnet's work, entitled *Médailles Romaines*,[1] is of far less importance. It has the two cardinal defects of not describing the most common types, and of following no scientific arrangement. There are several excellent essays on particular branches of the subject, which we shall have occasion to notice in subsequent places.)

Chief classes of Roman coins.

Without considering in detail every kind of Roman money, it will be necessary to make some observations on the chief classes, the early proper coinage of the city, the family series, and that of the empire. Of the first kind, the æs grave is beyond doubt the most important portion. It must not be supposed, however, that it is all of Rome; for it is certain that much was issued by other cities, although there is a great quantity that we must believe to be properly Roman. The as of Rome is known by having on the obverse the head of Janus bifrons, and on the reverse the prow of a galley, to which Ovid alludes, asking—

"Cur navalis in ære
Altera signata est, altera forma biceps?"

(*Fast.* i.) Other denominations have different obverses, with the same reverse, and must have been struck at Rome or under Roman authority. Coins of other types are to be generally referred to cities in the neighbouring provinces. (The most complete work on the æs grave is that by MM. Marchi and Tessieri, already noticed.)

Family series.

The series of family coins consists mainly of denarii, other pieces, both in gold and silver, being comparatively rare, and even the copper money of the same class being not so numerous, and showing far fewer varieties. The types of the denarii are of high interest, especially when they relate to the Roman traditions, or to earlier or contemporary history. Those that refer to the story of Romulus, or bear the heads of others of the primæval kings, or commemorate events assigned to this first age of the city, show how strong a hold the early Roman legends had taken upon the mind of the people in the first and second centuries before the Christian era, at times mainly anterior to similar written evidence. These types are for the most part not the common devices of the nation, but proper to each family; and they thus indicate the general feeling more clearly than those of Greek cities, which gave no scope to individual choice. The family coins that record the achievements of the house, whether in days past or in the time when they were issued, are also of high interest. The memory of events not yet recognised in written history is thus preserved, and in such a manner as to lead us to hope that we may, with the aid afforded by the coins, restore otherwise lost portions of the annals of the city. It is important to observe,—there can be no doubt, owing to historical considerations, differences of style, and evidently local types,—that many family coins were struck not alone out of the city, but in provinces beyond Italy. We may notice a few of the types of denarii, taking the families in an alphabetical order. Of the family Æmilia there are interesting coins relating to deeds performed or structures raised by members of that house. One bears the head of Alexandria on the obverse, and on the reverse Marcus Lepidus crowning Ptolemy Epiphanes. Another has a representation of Paulus Æmilius as if raising a trophy, with Perseus, king of Macedon, and his two children, standing before him. The coins of Mark Antony, which belong to the family Antonia, display his power and arrogance. To Junia is assigned the money of the celebrated Brutus. The most remarkable coins in the family series, were they undoubted, would be those of Brutus commemorating the death of Julius Cæsar, with on the reverse a cap of liberty between two daggers, and the inscription EID. MAR. There are specimens in both gold and silver, the latter having two types of obverse; but we have seen none that could be pronounced satisfactory. Dio Cassius indeed says that such a commemorative type was placed on his coins by Brutus; but it is not unlikely that all the pieces bearing it would have been called in by the triumvirs, while the passage would have stimulated modern forgers to produce what it describes. Among the types of the coins of the family Marcia we notice the head of King Ancus Marcius. The coins of the family Pompeia are of great interest. The most remarkable one has on the obverse the Pharos of Messana above a Roman galley, and on the reverse Scylla striking with a rudder; types supposed to relate to the defeat of the fleet of Octavianus, B.C. 38, near Messana, by that of Sextus Pompey; or possibly referring to the earlier battle in the straits of Sicily, B.C. 42, between the same, and with the same result. The coins of the family Tituria present two noticeable types, one representing the Romans carrying off two Sabine women, and thus commemorating the Rape of the Sabines, and the other, Tarpeia being crushed by bucklers. (The best work on the family coins is that of M. Cohen.[2])

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Coins of the empire.

The imperial series is properly the continuation of the family class, although characterized by marked distinctions. The denominations present a more perfect system, as we might have expected; and the reference of the types is either to the state or to the emperor. The types of the later family coins, however, from the time of Sylla, when the liberties of Rome were already overthrown, are very frequently similar in intention to those of the imperial money. The whole class may be separated into three main divisions, the first comprising the coins of the period extending from the rule of Julius Cæsar to the death of Commodus; the second, those of the subsequent time, as far as the accession of Constantine; and the third, those of that sovereign and his successors to the fall of the Empire of the West. The coins of the first period have that general character of order and fitness that we should expect in the money of a great empire, and at the same time show such changes as would be made by a nation which despised commerce, and was strong enough to carry its contempt into acts. Under the outward system of regularity there lay an element of disorder that brought about in the end financial ruin. The principles that worked little harm in an age of prosperity were engines of destruction when the state was overtaken by adversity. No longer sustained by a powerful government, or applied with moderation, slight changes took the form of desperate experiments, each one of which left the exchequer in a position of greater difficulty. In the period we are now noticing, we find but the commencement of this disorder in the constant though small decline of the weight of gold and silver coins, and the legalization of their moderate reduction, a system which did but continue the custom of the commonwealth, under which there had been far greater changes. The chief coins are the aureus, the denarius, the sestertius, the dupondius, and the as. Denominations lower than these are not common. There is a general similarity of types, especially in the case of the aurei and denarii. On the whole, the best work is shown in the sestertii; but the dupondii are often excellent, as well as the aurei and denarii. The types have for the most part a reference to the emperor rather than to the state, although this is less marked at the first than afterwards. The coins of Augustus show a decided advance in their art upon those of Julius; but in this respect they must yield to those of Livia, Antonia, and Agrip-

[1] *De la Rareté et du Prix des Médailles Romaines*, par T. E. Mionnet, 2de éd., 2 vols. 8vo, Paris, 1827.
[2] *Description Générale des Monnaies de la République Romaine*, par H. Cohen, 4to, Par. 1857.

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pina the Elder, which are among the most excellent Roman coins. The portraits of Livia, as Salus, Justitia, and Pietas, on dupondii, are among the most beautiful examples of Græco-Roman art. The bust of Antonia on aurei and denarii, as Ceres or Proserpine, is a finer subject, scarcely less ably treated.[1] The portrait of the elder Agrippina on sestertii is quite equal to those of Livia in work, although the face is not so beautiful. The coins of Drusus Senior bear types relating to his conquest of the Germans. The denarius of Tiberius is interesting on account of the description of it in the New Testament with reference to the question of the lawfulness of paying tribute. The sestertii of Nero are of very fine work, and in this respect yield to no other coins in the series. The money of Vespasian and Titus records the subjugation of Judæa. The coins of Trajan are remarkable for their architectural types; and those of Hadrian as commemorating his journeys. The portrait of Antoninus Pius is fine; and that of the elder Faustina is among the most beautiful. The head of Marcus Aurelius is also well executed; and that of the younger Faustina is always beautiful, and sometimes inferior to none in the series, when the empress is represented as very young, probably in the character of Venus, whose name and figure occupy the reverse. The imperial ladies are distinguished by the manner in which they wear their hair, which is sometimes a safer guide than the portrait. The coins of Commodus may be considered to close the series of those showing good art: some of them display great delicacy and careful work. Among the more interesting pieces is the copper medallion, having on the reverse Roman Britannia seated.

Coins of the empire.

The disorders that followed the death of Commodus have left their impress on the coinage, which then lost its beauty of design and delicacy of execution, neither to be more than partially restored in after times. The money of Severus and his house, which shows systematic lowering of value, is of interest. The base metal argenteus is already found in the time of Niger, but it was not regularly introduced until the reign of Caracalla. The coins of Elagabalus are remarkable for their reference to the oriental worship to which he was attached. Under Alexander Severus, the copper money was legally reduced, and great attention was paid to its execution, which is excellent for the period. The art and purity of the money declined after Alexander's reign, and in that of Gallienus both had sunk to a very low condition. The chief coins of this emperor, and the so-called "Thirty Tyrants," were the argentei, which were of copper or base metal washed with silver, and brass pieces of the same size, commonly called "third brass," which are first plentiful at this time. With the accession of Aurelian the Greek imperial money may be considered to cease, except at Alexandria; and thenceforward very much of the Roman coinage was struck in the provinces. After a time we notice the abbreviated names of the towns of mintage in the exergues of the coins; a practice which appears to have commenced in the reign of Gallienus, but not to have attained a regular form until that of Diocletian and Maximian. About the period of the latter, Treves, Lugdunum (*Lyons*), Arles, Londinium, Rome, Constantinople, Antioch, Alexandria, and Carthage, and afterwards Ravenna and Milan, are the most common mints. The changes of Diocletian, although they improved the material of the coins by substituting pure silver pieces for the base argentei, and added the large copper follis to the third brass, did not materially affect the types. Throughout this period they are of inferior interest to those of the prosperous age that preceded it. Their reference is rather to divinities than to events, and they show a want of originality. With Diocletian, however, the art of the coins improves, a stiff style being introduced, which, notwithstanding its radical faults, is not devoid of force. In the treatment of heads it is more happy than in that of groups.

The commencement of the third period of Roman coinage we have dated in the reign of Constantine the Great. The proper beginning cannot be exactly fixed; for it would be difficult to choose between the monetary changes of this emperor and his abandonment of pagan designs and adoption of others, either connected with Christianity or supposed to be not repugnant to it. The two events do not, however, seem to have been far apart. The recognition of Christianity was not the cause of such great immediate changes in the types as one might have supposed. A little earlier several types of a symbolical or allegorical character had been introduced, and these were retained. The Christian types at first are very few, and they can scarcely be said to predominate during any part of the remaining period of the Western Empire. The art of Constantine's money resembles that of Diocletian's; but after his time there is a speedy decline, and towards the close of the empire the coins are in this respect very poor. The most interesting coins are the third brass pieces of Constantine, with the Christian monogram upon the standard (*labarum*), and the somewhat later folles, as those of Vetranio, with the inscription HOC SIGNO VICTOR ERIS. The coins of Julian the Apostate are to be noticed on account of their showing a recurrence to purely pagan designs. On the whole, it may be considered that the change of religion was fatal to the types of the coins, no doubt because it took place at a time when the art of the empire was in too low a condition to be capable of expressing new ideas.

Mediæval and Modern Coins.

Sect. V.—MEDIÆVAL AND MODERN COINS OF EUROPE.

The period of the mediæval and modern coins of Europe must be considered to commence about the time of the fall of the Western Empire, so that its length to the present day is nearly 1400 years. The many groups into which this great class is divided are so remarkably different from one another that it cannot be treated, like the Greek or the Roman series, as a whole. It is also impossible to separate the mediæval and modern coins, either in the entire class, because the time of change varies, or in every group, since there are usually pieces indicative of transition which display characteristics of both periods. The clearest division is, to place the Byzantine coinage first alone, and to consider the rest of the class as possessing a kind of general similarity, though of the widest sort.

Byzantine empire.

The Byzantine money is usually held to begin in the reign of Anastasius, A.D. 491–518. The coinage is always in the three metals, but the silver money is rare, and was probably struck in small quantities. At first both the gold and the silver are fine, but towards the close of the empire they are much alloyed. The types, except when they refer simply to the sovereign, are of a religious, and consequently a Christian character. This feeling increases to the last. Thus, on the obverse of the earlier coins the emperors are represented alone, but from about the tenth century they are generally portrayed as aided or supported by some sacred personage or saint. On the reverses of the oldest coins we have such types as a Victory holding a cross, but on those of later ones, a representation of our Saviour or of the Virgin Mary. Subsequently some allegorical religious types are introduced, as that of the Virgin Mary supporting the walls of Constantinople. The principal inscriptions for a long period almost invariably relate to the sovereign, and express his name and titles. The secondary inscriptions of the earlier coins indicate the town at which the piece was struck, and, in the case of the larger copper pieces, the year of the emperor's reign is also given. From about the tenth century there are generally two principal inscriptions, the one relating to the emperor, and the other to the figure of our Saviour. The secondary inscriptions at the same time are descriptive, and are merely abbreviations of the names or titles of the sacred personages near the representations of whom they are placed. From the time of Alexius I., Comnenus, the principal inscriptions are almost disused, and descriptive ones alone given. These are nearly always abbreviations, like the secondary ones of the earlier period. The language of the inscriptions was at first Latin, with a partial use of Greek; about the time of Heraclius, Greek began to take its place on a rude class of coins, probably local; by the ninth century Greek inscriptions occur in the regular coinage; and at the time of Alexius I. Latin wholly disappears. The Greek inscriptions are remarkable for their orthography, which indicates the changes of the language. Of the art of these coins little need be said. It has its importance in illustrating contemporary ecclesiastical art in the East, but is generally inferior to it in both design and execution. The denominations, except those of the gold money, present matter for careful inquiry, little that is definite

[1] The beautiful bust in the British Museum, usually called that of Clytie, probably represents a Roman lady of the early days of the empire. That it is the work of a Græco-Roman artist, and—whether meant to be an ideal subject or not—the portrait of a Roman lady, admits of no doubt. In time it must be, judging from its style, of the first century of the Christian era; and the manner in which the hair is worn points to the earlier part of that period. The lady represented may be only a private person, but the excellence of the work makes it far more probable that she is of an imperial family. On a comparison with the coins, it will be noticed that the head bears a great resemblance to that of Antonia, with whose character the simple modesty of its expression, unexcelled in portrait-sculpture, would well accord. That Antonia is represented on some of these coins as Ceres or Proserpine, agrees with the conceit of the sculptor, who has made the bust to spring from a flower.

Mediæval and Modern Coins.

having been ascertained respecting them. The chief gold piece was the *solidus* or *νόμισμα*, which maintained its just weight, as established by Constantine, for near 1000 years from the reign of Anastasius until the latter days of the Empire of the East, and without diminution of purity except during the time of disaster that closed this long period, its corruption commencing under the Comnenian princes. This accuracy rendered the solidi famous in the commerce of Europe, so that they were the principal gold pieces, not alone of the East but of the West also, before the issue of florins and ducats by the cities of Italy. The smaller gold pieces were the half and third of the solidus, as in the late Roman coinage, but after a time they were both disused, and the solidus was alone issued. In the eleventh century the solidus begins to be struck in a very concave, or rather a cup-shaped form; and this kind soon supplanted the old flat coin, and continued to the taking of Constantinople. The silver and copper pieces take the same shape, but not so consistently. These concave coins are termed *nummi scyphati*. The silver money of Justinian I. has more denominations than that of the close of the Western Empire, but they are not satisfactorily determined and identified. In the reign of Heraclius, in A.D. 615, a large silver piece, weighing six grams, and therefore called a *hexagram*, was issued: its weight is about 105 grains. During the eleventh century concave silver pieces were issued, as well as flat and somewhat thick ones of a smaller size and lesser weight. The Byzantine copper money falls into two great classes, the first commencing under Anastasius and ending under Basil I., and the other beginning under Leo VI. and extending thence to the close of the empire. The former class is distinguished by the coins bearing numerals indicative of their value. It follows three systems,—that of the empire generally, that of Alexandria, and that of Carthage. The unit was the coin called *νουμμίον* or *λεπτόν*. Under Justinian I., or about his period, we observe coins of the empire generally, with on the reverses the following indexes of value:—M, K, I, E, Δ, Γ, B, and A, or 40, 20, 10, 5, 4, 3, 2, and 1, nummia; the Latin equivalents of certain of these being given on some coins, chiefly of western mints, and the index XXX also occurring without a Greek equivalent. Anastasius, in A.D. 498, reformed the copper coinage, and struck pieces with the index occupying the greater part of the reverse, and having beneath it the abbreviated name of the place of issue. Justinian I. added, in the coinage of his twelfth year, A.D. 538, the regnal year. The weight of this copper money presents extraordinary variations, which indicate the condition of the imperial finances from year to year. There is, as might be expected, a decline which is constant, although irregular. The Alexandrian coins commence under Anastasius, and terminate with the capture of the city by the Muslims. They have two denominations, marked respectively IB and S, as containing 12 and 6 nummia, the former of which forms the great bulk of the copper money, and maintains its weight with tolerable accuracy. Some of these pieces of the reign of Heraclius, struck while his sons Heraclius Constantinus and Heracleonas were associated with him, have the double index IB and M, a circumstance explained by the depreciation of the copper money of the empire generally, while that of Alexandria retained almost its just weight. There is an isolated Alexandrian coin of Justinian I., with the index ΛΓ (33), of great rarity: it was probably issued as an experiment, and never subsequently struck. The monetary system of the Vandals at Carthage is an offshoot of the Byzantine. It probably lasted from the accession of Huneric to the capture of the city and dethronement of Gelimer; but the pieces bearing indexes of value have no sovereign's name. The indexes are XLII, XXI, XII, and IIII. The system must be regarded as a double one, comprising a piece of 42 and its half, and one of 12 and its third, the relation of all being, if we take the piece of 12 as the unit, for the sake of convenience, 3·5, 1·75, 1, and ·33. Under Basil I. there was a reform, and larger copper pieces were issued. The second class of Byzantine copper coins begins under Leo VI. The denominations are at first evidently the same as those of the preceding class.

Besides the regular series of the Byzantine Empire, in which we include the money assigned to the Latin emperors of Constantinople, there are several groups connected with it, either by their similarity, or on this account, and also because the sovereigns were of the imperial houses. The former of these two classes comprehends the money of the Ostrogoths struck in Italy, that of the Vandals in Africa, and that of the Visigoths in Spain. The last series is wholly of gold pieces, which, notwithstanding their barbarism, are of interest, as showing the wealth of the kingdom. The latter class comprises the money of the emperors of Nicæa, of Thessalonica, and of Trebizond. The last group consists of small silver pieces, which were prized for their purity: they were called Comnenian aspers (*ἄσπρα Κομνήνατα*), the princes of Trebizond having sprung from the illustrious family of the Comneni. (The best work on the Byzantine coinage generally is M. de Saulcy's *Essai*.[1] The Letters of the Baron Marchant[2] contain much that is valuable; and the treatise of M. de Pfaffenhoffen on the coins of the empire of Trebizond[3] should also be consulted.)

Mediæval and Modern Coins. Sub-Byzantine groups.

The class comprising the rest of the mediæval money may now be generally described, before we briefly notice its several divisions with their modern continuations. The oldest of these coins are imitations, more or less barbarous, of the late Roman and early Byzantine money. They are usually of gold, and represent the solidus and its divisions. In Italy, where much of the civilization and art of the Romans yet remained, the coins of the Lombard kings of Italy and dukes of Benevento are not greatly inferior to the contemporary coins of the Greek emperors. In France, the Merovingian sovereigns struck pieces which are sometimes even more faithful imitations than these. Britain, most completely cut off from civilization after the departure of the Romans, first issued barbarous and blind imitations of the smallest Roman copper coins latterly in circulation, and then little silver pieces, with types sometimes of the same origin. In Spain, the gold money of the Visigoths, already mentioned, is in its general character similar to that of the Merovingian kings of France.

Other mediæval coins.

A little before the commencement of the German Empire a new class of coins began to be issued, mainly consisting of two denominations,—the denier, of silver, derived from the denarius; and its half, the obole, which was first of silver, but afterwards of billon, and took its name from the obolus. These pieces rapidly supplanted the gold currency, although the imitation of the solidus, called the *sol d'or* or *soldo d'oro*, and its divisions, continued to be struck in France and Italy. The characteristic money of the middle ages begins with these coins. Though we still perceive the influence of Roman ideas, the effect of a new system is apparent, not alone in the types of many of the pieces, but in the extension of the right of coinage. The principal coins of this class are of the German Empire, of France, of the Scandinavian states, and of England, and commence about the middle of the eighth century, lasting until the revival of art. Except in the empire, the denier was almost exclusively struck, and known as the penny or sterling. The coins were issued not alone by the emperors and kings, but also by the ecclesiastical princes and lords; and, except in England, where the right was almost always more restricted, by the feudal lords and the heads of religious houses. The most common types of imperial and regal coins are, for the obverse the bust of the sovereign, and for the reverse what is commonly termed a Greek cross, varying in form, accompanied respectively by the royal name and titles, and the name of the place of mintage, or of the moneyer, or both. The feudal lords and the ecclesiastics gradually adopted badges or distinctive types, those of the former being of a rude heraldic character, those of the latter having a religious meaning, though with a necessary local reference. The religious types also occur on the coins of sovereigns when struck at cathedral towns. Towards the close of the twelfth century the singular pieces called *bracteates* appear. They were issued in Germany, and seem to have been extremely common during the thirteenth and fourteenth centuries, after which period they ceased. They are coins of silver or billon, sometimes large, but very light, and bearing a single design, usually of very barbarous work. From their extreme thinness, they have the appearance of tinfoil impressions of coins. They often do not bear even a

[1] *Essai de Classification des Suites Monétaires Byzantines*, par F. de Saulcy, 8vo, Metz, 1836 (with a volume of plates).
[2] *Lettres du Baron Marchant sur la Numismatique et l'Histoire*, nouvelle éd., 8vo, Paris, 1851.
[3] *Essai sur les Aspres Comnènats, ou Blancs d'Argent, de Trébisonde*, par F. de Pfaffenhoffen, 4to, Paris, 1847.

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single letter, and rarely a full inscription, and there is therefore frequently much difficulty in ascertaining their proper attribution. During the time of the bracteates civic coins commence, issued by imperial cities, or free cities, or by corporations of towns under ecclesiastical or feudal lords.

The first pieces which display any excellence in art are those of Italy, struck for the emperor, or for the various states, in the time of Frederic II. That sovereign's Italian money affords remarkable evidence of the revival of art; but we do not see as great an advance in other countries. From this time, however, or not long afterwards, until the early days of the sixteenth century, there is a constant progress everywhere, and the coins, although they scarcely add to our historical knowledge, are interesting as works of art. The denominations of both gold and silver money are very various, and some have several appellations in different countries when there is not a sufficient change of weight, style, or appearance to justify their being so separated. The basis of all the systems is, however, to be traced to the commercial cities of Italy, from the florins and ducats of which, the former either of gold or silver, the principal coins of other countries were derived. In the middle of the fifteenth century medals commence, and for about a hundred and fifty years are frequently of high merit and interest. It may be mentioned that the mediæval silver coinage is on the whole the most important, the gold almost failing from the time of the decay of Roman influence until that of the revival of art, and the copper being much neglected, and sometimes altogether abandoned, until near the close of the middle ages.

It is not necessary to speak at any length of the general characteristics of the modern coins and medals of European states and their colonies. In all that is technical, as in the preparation of the metals, the convenience of the form, and the mechanical execution, the moderns have far surpassed their predecessors; but in the beauty and meaning of the types they are at as great a distance below them, and immeasurably below the Greeks. The French medals of the first Napoleon are alone in the least comparable with the earlier pieces of the same kind. We will not here enumerate the denominations; but it may be noticed that the sovereign and the dollar, sometimes yielding to the shilling, which may be termed its quarter, all with various appellations, but little difference of weight, are the principal gold and silver coins of both hemispheres.

Art.

It would be interesting, had we space, to notice fully the art of this entire class, to examine its growth, and to trace its decline, but, as with that of Greek and Roman coins, we must limit ourselves to the best period. This is a space of about a hundred and fifty years, from the middle of the fifteenth century to the close of the sixteenth. The numismatic art of this time may not unworthily be placed by the side of its sculpture and its painting. Not alone have some of its medallists taken honourable places in a list where there was no room for ignoble names, but to design medals was not thought an unworthy occupation for the most famous artists. There are, as we should expect, two principal schools, the Italian and the German. The former attained a higher excellence, not alone as possessing a finer style, but one especially adapted to coins or medals. The object which the artists strove to attain was to represent a head, or to commemorate an action, in the best manner possible, without losing sight of the fitness of the designs to the form and use, real or imaginary, of the piece on which they were to be placed. For the successful attainment of this purpose, the style of the later pre-Raphaelites was eminently suited. Its general love of truth, symmetrical grouping, hard drapery, and faithful though cold portraiture, were qualities especially fitted to produce a fine portrait and a good medal. The less sculptural and more pictorial German art was not so suitable to numismatic designs. The portraits of the German coins and medals are often more characteristic than those of the Italian, and the groups have sometimes greater expression; but both are less appropriate. They show also too great a profusion of detail, by which the effect of the boldness of the outlines is frequently lost; yet they display great originality and vigour, and will reward an attentive study. Both these schools, but especially the Italian, afford the best foundation for a truly excellent modern medallic art. The Greek and Roman coins are rather to be studied as examples of art in general than of this especial art, although they supply the most useful suggestions. To copy for a modern piece the design of a Greek or Roman coin is as inappropriate as it is to represent an English general in the garb of a Greek hero in one place, and in that of a Roman statesman in another. The finest coins and medals of Italy and Germany have an object far more similar to that we seek to fulfil in our own, and their nearness in time makes many details entirely appropriate. Thus, without blindly imitating them, our artists may derive from them the greatest assistance.

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(The most useful works on mediæval and modern coins generally are, Appel's *Repertorium*;[1] the treatises of Mader[2] and Lelewel;[3] and, for current money, the *Encyclopédie Monétaire*.[4])

We do not purpose to enter in any detail into the various divisions of the subject we have treated in its main outlines. The questions that would require consideration are of two complicated and technical a nature to be illustrated in the present essay within any reasonable limits: our endeavour will therefore be merely to indicate the principal matters of inquiry, and the most serviceable books for the student's use.

Portugal and Spain.

The money of Portugal is regal, and not of great interest. It affords indications of the wealth and commercial activity of the state in the early part of the eighteenth century. There is no special work upon it. The coinage of Spain is, almost without exception, regal, but a more curious class than that of Portugal. The coins of the early contemporary kingdoms, such as those of Arragon, and of Castile and Leon, are especially worthy of examination. We may mention, as of a very peculiar character, a large gold piece in the coinage of the latter state, called the *Dobla de la Vanda*, from its bearing the shield of the famous order of knighthood of the Vanda or Band. Of this there are examples assigned to John I. (1379–90) and John II. (1406–54). The money of the sole monarchy is less worthy of notice. The city of Barcelona is represented by coins bearing the names of various kings, except in the case of those issued at the time of the Peninsular war. The medals of Spain are not important. (There is no complete work on mediæval and modern Spanish money, but the catalogue of M. Gaillard, referred to in speaking of the ancient coins of Spain, will be found of service in this department also.)

France.

The coinage of France forms a large series. It begins with the money of the Merovingian dynasty. This consists almost wholly of gold pieces, imitated from those of the late Roman and Byzantine rulers, as already mentioned, the chief denomination in commerce being the tremissis, or third part of the sol d'or (solidus). The coins are rare, and bear either the names of a king and city, or of a moneyer and city. They are of different degrees of barbarism in their art. Under the princes of the Carlovingian dynasty the principal coins are deniers, and after a time oboles also, gold money being extremely rare. They bear the name of the king and that of the city where they were struck, and have a more original character than the earlier pieces, although they are still barbarous. The money of the Capetian house commences with coins like those of the line preceding it. By degrees the coinage improves. In the thirteenth century gold pieces were issued. There are several denominations of these and of silver coins, but to some different names are applied for various types with the same weight, as the *denier Parisis* of Paris, and the *denier Tournois* of Tours. At the time of Philip VI. the coins are fine. The modern coinage may be considered to commence under Henry II., whose portrait is of good work. During this period there is no very remarkable feature in the current money, except the occurrence in the seventeenth century of the pieces of the sort termed *pied fort*, which we must regard as a kind of patterns. The seignorial coins of France are, during the middle ages, of considerable importance, though inferior to the similar classes of German and Italian money. The medals are far more interesting than the modern coins. Their interest begins in the age of Louis XIV., but they take a fresh character under the first republic and the reign of Napoleon I. Almost every great event, from the beginning of the power of the emperor until his fall, is worthily commemorated in this series, unequalled in its class for extent, completeness, and excellence. The designs, notwith-

[1] *Appel's Repertorium zur Münzkunde des Mittelalters und der neuern Zeit*, 4 parts in 7 vols. 8vo, Pesth, 1820–22; Wien, 1824-1829.
[2] *Kritische Beyträge zur Münzkunde des Mittelalters*, von Joseph Mader, 6 vols. 8vo, Prag. 1803–1813.
[3] *Numismatique du Moyen-Age, considérée sous le Rapport du Type*, par J. Lelewel, 3 vols. 8vo, Paris, 1835, and vol. of plates, &c.
[4] *Encyclopédie Monétaire, ou Nouveau Traité des Monnaies d'or et d'argent en circulation*, &c., par A. Bonneville, fol., Paris, 1849.

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standing that mannerism which appears to be essential to modern French art, are vigorous in drawing, and executed with great care and skill. The intention of each subject is well carried out, if we make the same allowance as before for national peculiarity of feeling; and equal success is shown both in realistic representation and in idealistic composition. No other series of medals is at all to be compared to this, although individual specimens of the mediæval period struck both in Italy and Germany are of a far higher style, more original, more vigorous, and altogether grander both in the idea of the artist and the form which he has given it. (The numismatists of France, especially of late, have displayed a most praiseworthy diligence; so that we cannot indicate a tenth of the useful treatises they have produced. On the regal coinage the works of Le Blanc,[1] and Fougères and Combrouse,[2] must be mentioned; on the seignorial, that of Duby;[3] and on the Napoleon medals, as we may term them, the volumes devoted to this subject in the series entitled *Trésor de Numismatique et de Glyptique*.[4])

England.

The English coinage, as before mentioned, commences with two uncertain classes, which, wherever struck, certainly formed the currency of the country during the interval from the departure of the Romans, about A.D. 450, until the issue of money with royal names by the Saxon kings, a practice which cannot be carried earlier than about a century after this event. One of these classes consists of imitations of the latest Roman copper money, and the other of the small silver pieces to which the name of *sceatta* is applied, having rude types which are sometimes of Roman origin, but sometimes original. In all probability the former were first issued, and then the latter. The regular coinage commences under the Heptarchy. There is money of the kingdoms of Kent, Mercia, the East Angles, and Northumbria. The chief coins are silver pennies, but sceattas also occur; and of Northumbria there are *stycas*, which are pieces of a base metal in the composition of which copper is the largest ingredient. The most interesting coins of this group are those of Offa, king of Mercia: these are silver pennies, remarkable for their quaint designs and their relatively careful execution. Of this period, but extending into the earlier part of that of the sole monarchs, there are coins issued by the archbishops of Canterbury and York. The money of the sole monarchs, whether Saxons or Danes, is strictly a continuation of that of the Heptarchy: it consists almost wholly of silver pennies, which latterly were cut into halves and quarters to form halfpennies and farthings. Under the Normans and earlier Plantagenets the same coinage continues; but under Edward III. there is regular gold money, of which the chief piece is the noble of six shillings and eightpence; and the silver groat, which supplanted the penny, has already commenced. The obverse-type of the noble, representing the king in a ship, probably commemorates, as suggested by Ruding,[5] Edward's victory over the French fleet off Sluys, A.D. 1340. At the same time, there is a visible improvement in the art of the coinage, which advances until, under the early Tudors, it attains its highest excellence, from which, however, it is speedily to fall. Of Henry VIII. we have gold and silver coins of most existing denominations, as well as of earlier ones long since abandoned. The finest piece is the sovereign, a large flat coin of gold, bearing on its obverse the figure of the king (whence its name) on his throne. With Queen Elizabeth the modern money may be held to commence, the Gothic character of the types giving place to the later and far less beautiful style. The coinage of Charles I. presents great varieties, owing to the civil war. The scarcity of silver in the royal treasury during the troubles induced the king to coin twenty and ten shilling pieces of silver, in addition to the crowns and smaller denominations. One of the most remarkable of his pieces is a crown struck at Oxford. It bears on the obverse the king on horseback, with beneath the horse a representation of the town, or rather of its principal buildings, and on the reverse the heads of the "Oxford Declaration." Of equal interest are the siege-pieces of many castles famous in the annals of those days. The coinage of the Commonwealth is of a plainness proper to the principles of those who sanctioned it. The great Protector, however, caused to be designed money of his own bearing his head. This seems never to have been sent forth, and is therefore put in the class of patterns. Simon, the chief of English medallists, designed the coins, which are unequalled in our whole series for the vigour of the portrait (a worthy presentment of the head of Cromwell), and the beauty and fitness of every portion of the work. Henceforward there is a decline in the coinage, although skill is perceived in the portrait of William III., whose grand features could scarcely have failed to stimulate an artist to more than a common effort. Queen Anne's money is also worthy of note, since one of her coins, the farthing, has been the cause of an extraordinary delusion. It is commonly imagined that a very small number (some say three) of these pieces were struck, and that their value is a thousand pounds each, instead of a few shillings. In consequence, many imitations have been forged, and such are constantly brought to collectors by unfortunate labourers and the like, who imagine that they possess the greatest numismatic treasure in the world. After this there is little to remark, except the baseness of the art of the coins under the first three Georges, until the genius of Pistrucci gave a worthier form to our currency, which the care and accuracy of Wyon has preserved without mere imitation. Besides the regal coinage, there is scarcely any baronial money, the class being represented by a few pieces, generally at least struck by personages of the royal house, and all belonging to the period of the close of the Norman line and beginning of the Plantagenet. The English tokens form a curious class. They are of two periods: the earlier, which are generally of brass, were issued at the middle of the seventeenth century and somewhat after; the later, which are mainly of copper, were struck during the scarcity of the royal coinage at the end of the last century, and during the earlier years of the present one. Both were chiefly coined by tradesmen, and bear their names. The medals of England are less important than those of France and Germany. Some of those of the Tudors, commencing with Henry VIII., are of good style. Those of the period of the Stuarts are more interesting than beautiful. During the civil war many pieces were struck commemorating the chief men and events of that time. The custom continued under the Commonwealth and after the Restoration; and there is a curious series of medals and what may be termed jetons, relating to the Popish Plot in the reign of Charles II. Of a later period are the medals of the two Pretenders and their family; but of our own times little worthy of note. The colonial money of England is unimportant until lately, when it is not unworthy of the wealth and activity of the dependencies. The money struck by the English kings for their French dominions forms a peculiar class, mainly French in its character, termed the Anglo-Gallic. This may be used to supply some gaps in the regal series of England, as, for instance, containing money of Richard I., of whom no English coins are known. (On the English coinage generally there is the great treatise of Ruding;[6] on the silver money, the very complete and accurate work of Mr Hawkins;[7] on the Anglo-Gallic coins, Gen. Ainslie's Essay;[8] on the medals, nothing better than the indifferent work of Pinkerton;[9] and on the tokens of the seventeenth century, a catalogue just published, which entirely meets the wants of the collector.[10])

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Scotland.

The coinage of Scotland is allied to that of England, although generally ruder; but it seems to have been more influenced in the early period from Scandinavia, and towards its close from France. The oldest pieces are probably silver pennies or sterlings, resembling the contemporary English money, of the commencement of the twelfth century. In the fifteenth and sixteenth centuries there is an important coinage, both in gold and silver, not the least interesting pieces being those of Queen Mary, many of which bear her portrait. The indifferent execution of the coins of this period is traceable to the disturbed state of the kingdom. (On the coinage of Scotland there is the old work of Cardonnel,[11] and the later one of Mr Lindsay.[12])

Ireland.

The money of Ireland is more scanty and of less importance than that of Scotland. The pieces most worthy of notice are the silver pennies of the early Norse kings. Of later times there is little that is interesting, except the coinage of James II. during his attempt to maintain himself in the island. (Mr Lindsay has written a work on the Irish coinage.[13])

Belgium and Holland.

Belgium occupies the next place in our arrangement. Its

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[1] *Traité Historique des Monnoies de France*, par M. le Blanc, 4to, 1690.

[2] *Description complète et raisonnée des Monnaies de la 2me Race Royale de France*, par F. Fougères et G. Combrouse, fol., Paris, 1837; Suppl. 1838.

[3] *Traité des Monnoies des Barons*, par M. P.-A. Tobiésen Duby, 2 vols. 4to, Paris, 1790.

[4] *Médailles de la Révolution Française* (1789–1804), fol., Paris, 1836; *Collection des Médailles de l'Empire Français et de l'Empereur Napoléon*, fol., Paris, 1840.

[5] *Annals of the Coinage*, vol. i., p. 219.

[6] *Annals of the Coinage of Great Britain and its Dependencies*, by Rev. R. Ruding, 3d ed., 3 vols. 4to, Lond. 1840.

[7] *The Silver Coins of England arranged and described*, by Edward Hawkins, 8vo, Lond. 1841.

[8] *Illustrations of the Anglo-French Coinage*, 4to, Lond. 1830.

[9] *The Medallic History of England to the Revolution*, 4to, Lond. 1790.

[10] *Tokens issued in the Seventeenth Century in England, Wales, and Ireland*, by William Boyne, 4to, Lond. 1858.

[11] *Numismata Scotica, or a Series of the Scottish Coinage from the Reign of William the Lion to the Union*, by Adam de Cardonnel, 4to, Edinburgh, 1786.

[12] *A View of the Coinage of Scotland*, by John Lindsay, 4to, Cork, 1845.

[13] *A View of the Coinage of Ireland*, by John Lindsay, 4to, Cork, 1839.

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coinage comprises many pieces struck by foreign rulers, and has little of an independent character, either in the regal or seigneurial class. It closely resembles the money of France and Germany. The series of Holland is similar in character until the period of the revolt of the Provinces. The medals are highly interesting, more especially those which were struck by the Protestants in commemoration of current events, many of which relate to the great contest with Spain. Such are the pieces recording the raising of the siege of Leyden, likened to the destruction of Sennacherib's army; the assassination of William the Silent; and the discomfiture of the Armada; affording striking indications of the zeal, the piety, and the confidence in the right which built up the great political structure of the Dutch Republic. After this time the medals lose much of their interest. (Among the many works on the coins of the Netherlands and Holland, we must specify that of Van der Chijs.[1])

Switzerland.

The money of Switzerland is of considerable importance, chiefly during the early period of its independence. The coins of both cantons and towns bear their ancient shields, drawn at first with a vigorous grotesqueness. There are also pieces of ecclesiastical lords, and others having the right of coinage in particular cities or districts. (The general works on German coins will be found to treat of those of Switzerland also, but we must mention the special essays of Haller[2] and Dr H. Meyer.[3])

Italy.

The coinage of Italy during the mediæval period is alone rivalled by that of Germany, which, moreover, it excels in some respects. First in Italy the revival of art influenced the coins, and in Italy each step of advance found in them its record. The oldest mediæval Italian coins are gold pieces of the Lombard kings of Italy and of the dukes of Benevento, occupying, as already mentioned, very much the same position in relation to the late Roman and the Byzantine money, as the earliest coins of Spain and France. The series of the kings of Italy is taken up by that of the emperors of Germany, which forms a remarkable class, especially as indicating the excellence of art here at a time when to the rest of Europe it was almost unknown. The great republics are worthily represented, their coins attesting by their purity, and the influence they seem to have exerted, the commercial energy of the states. Of Venice there is a long series, for the chief part bearing the names of the doges. Florence contends with Venice in the extent and purity of her coinage. Her florins of gold were for a great period as famous in European commerce as the gold ducats and silver matapans of her rival. The types of the florins—the lily of Florence, and the Baptist—were copied by the feudal lords of more northern lands, to the swamps of Holland and the shores of the Atlantic; the designs of the matapans—one of which, the doge receiving the gonfalone from St Mark, was yet more distinctive—were adopted by the half-barbarous tribes whose territories were the fighting-ground in the long contest of the German and the Turk. The medals of Florence, which are anterior to the time of the dukes, or those issued by them, not to omit the works of Florentine medallists which are not otherwise connected with their native state, are among the chief monuments of the numismatic art of Italy. The chief value of these medals lies in their bearing admirable portraits of persons of celebrity. Passing southwards, the series of Rome is of the highest historical and artistic value. It is for the greatest part struck by the popes, of whom there are both coins and medals. The later pieces commemorate the events of each reign, and are, as might be expected, of high excellence in style, although, from the excessive fondness of the artists for allegory, they are generally wanting in simplicity, and do not directly seize the attention. Another fault is partiality without invention or vigour. We may instance the medal of Gregory XIII. recording the Massacre of St Bartholomew, both for its reverse-type, an angel slaying the Huguenots, and the inscription VGONOTTORVM STRAGES. Far superior is the satire of some of the medals of the Dutch Protestants, and the dignity of others. Since the seventeenth century, few papal medals have been struck that are entitled to even moderate praise; those of the present day are beyond measure poor and weak. We must also mention the money of Naples, especially the oldest, which is of its strong Norman princes, who, supplanting the Arabs in Sicily, at first there struck their coins with legends partly or wholly in Arabic characters, while on the mainland they issued the ordinary money of the day. Many other groups might be mentioned, as the coins of the Visconti and Sforza families of Milan, of the D'Esté of Ferrara, and many more houses great in their love of arms and in their protection of art. (The coinage of Italy is amply illustrated by excellent essays, mainly of the last century. We must particularize those of Argelati,[4] Zanetti,[5] Bellini,[6] Carli-Rubbi,[7] and Fioravanti.[8])

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Germany.

The money of Germany is, like that of Italy, far too various for us to be able to do more than sketch some of its main features. It comprises three great classes,—the coinage of the emperors, that of the electors, and that of the smaller princes, the religious houses, and the towns. The imperial money, even when limited to what is strictly German by the exclusion of pieces struck in France and Italy, forms a very large series. Its chief characteristics are the same as those of the other great mediæval classes, except that, until near the close of the middle ages, it is considerably backward in its art. At this time its portraits are very characteristic, as well as the current coins as on the medals and the double-dollars, which are virtually medals. Of especial excellence is the medal of Maximilian I. and Mary of Burgundy, struck on their marriage; and the still finer medal of Maximilian, bearing on its obverse the emperor on horseback, fully armed, and said to have been designed by Albert Dürer, of whose hand it is not unworthy. The coinage of the archbishops of Cologne is a remarkable series. In the earlier period it bears representations of the cathedral, as is not unusual on ecclesiastical money of the time. The coins of Mayence, although they yield to those of Cologne in number and importance, form a large group. Of the dukes of Saxony there are fine dollars, which, at the period of the Reformation, bear vigorous and characteristic portraits. Of Treves there is another curious class, resembling that of Cologne. Besides these, there are very numerous bracteates and later pieces of temporal lords, of bishops and abbots, and of cities, some of which are free. (The treatises on this branch are many and excellent. We must specify those of Joachim[9] and Cappe,[10] besides remarking that the general works of Mader and Appel, before mentioned, give very large information on German money.)

Denmark, Norway, and Sweden.

The coins of the Scandinavian states—Denmark, Norway, and Sweden—are almost wholly regal. There are a few civic pieces, but the ecclesiastical bracteates assigned to this group are probably for the most part of Northern Germany. The regal money of these states is closely connected. In the earlier period it resembles the English and Scottish coinage, although with a national character of its own; afterwards it is more like that of Germany. There are some medals of historical interest. (This branch has not received the attention it merits, and there is no complete essay upon it. The great Danish work on medals, however, will be found to contain very full materials.[11])

Russia.

The coinage of Russia is mainly of the modern period, and, until comparatively recent times, shows a remarkable degree of barbarism. The medals are of no intrinsic merit, their sole value being historical. Both coins and medals are regal, except such of the former as were struck in cities now included in Russia, while yet under Sweden. (The work of Baron de Chaudoir will be found to give a good account of Russian money.[12]) The coins of Poland are mainly of the kings, and resemble those of the Hungarian kingdom. Of the states between Germany and Turkey there are interesting coins. The kingdom of Hungary and the principality of Transylvania are each represented by an important series, that of the latter comprising large and remarkable gold pieces of the sixteenth and seventeenth centuries. There are early coins of the patriarchs of Aquileia, and of the kings of Servia. The money of the Turkish Empire is of the oriental class, but there are many coins struck by Christian states in its present territories. This class may be called that of the Crusaders, comprising money of the princes of Achaia, and the dukes of Athens, in Europe; and of the kings of Cyprus and Jerusalem, the princes of Antioch, and the counts of Edessa and Tripolis, in Asia. This is very similar to the contemporary mediæval money. A kindred series is that of the knights of Rhodes and Malta, which bears testimony to the wealth and power of that

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[1] *Verhandelingen, uitgegeven door Teyler's Tweede Genootschap*, 4 vols. 4to, Haarlem, 1851–5.
[2] *Schweizerisches Münz-und Medaillenkabinet beschrieben*, von G. E. von Haller, 2 vols. 8vo, Bern, 1781.
[3] *Die Bracteaten der Schweiz*, &c., von Dr H. Meyer, 4to, Zürich, 1845.
[4] *De Monetis Italiæ Variorum Illustrium Virorum Dissertationes*, &c., P. Argelatus collegit, &c., 6 vols. fol., Med. 1750-1759.
[5] *Nuova Raccolta, delle Monete e Zecche d'Italia*, di G. A. Zanetti, 5 vols. 4to, Bologna, 1775–1789.
[6] *V. Bellini de Monetis Italiæ Medii Ævi Dissertatio*, 4to, Ferrariæ, 1755; *Altera Dissert.*, 1767; *Postrema Dissert.*, 1774; *Novissima Dissert.*, 1779.
[7] *Delle Monete e dell' Instituzione delle Zecche d'Italia*, &c., *Dissertazioni*, del Conte Don G. Carli-Rubbi, 4to, Mantova, 1754.
[8] *Antiquiores Pontificum Romanorum Denarii*, &c., à V. C. J. Vignolio, iterum prodeunt studio, &c., B. Floravantis, 4to, Rom. 1734.
[9] *Neu-eröfnetes Groschen-Kabinet*, 13 vols. 8vo, Leipz. 1739-1769.
[10] *Die Münzen der Deutschen Kaiser und Könige des Mittelalters*, von H. P. Cappe, 2 vols. 8vo, Dresden, 1848–1850; *Beschreibung der Cölnischen Münzen des Mittelalters*, 8vo, Dresden, 1853.
[11] *Beskrivelse over Danske Mynter og Medaille i den Kongelige Samling*, fol., Kiöbenhavn, 1791, and vol. of plates.
[12] *Aperçu sur les Monnaies Russes*, &c., par le Baron S. de Chaudoir, 2 vols, 8vo, St Pétersbourg, 1836–7, and vol. of plates.

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illustrious order. (We must mention, in illustration of this group, M. De Saulcy's account of the money of the Crusaders.[1])

America.

Respecting the coinage of America it is needless to enter into detail. Neither the money of the Spanish and Portuguese dependencies, and of the later states, nor that of the English colonies and the United States, present much that is worthy of note. The coinage resembles that of the parent countries, but is of coarser work. The dollar is the chief denomination. There are some coins of historical value, as those with the portrait of the Mexican emperor Augustin; and in the north, Lord Baltimore's pennies. (The *Encyclopédie Monétaire*, before mentioned among general works, will be found to be of great use in this branch.)

Sect. VI.—ORIENTAL COINS.

Oriental coins are of two great classes, the Pagan and the Mohammadan. (On both classes the great work of Marsden should be consulted.[2]) The first division is separated into the coins of the Persian Empire, the Parthians, and the Sassanians; of Bactria, and of the Hindus; and into those of transgangetic India, China, and Japan.

Persian imperial coins.

The Persian coins probably range from the commencement of the reign of Cyrus, or his capture of Babylon, to the overthrow of the empire by Alexander the Great, a period of about two centuries. The only pieces we can positively attribute are of satraps of the later kings. There can be no doubt, however, that we possess specimens of almost every reign, except the very short ones, from that of Cambyses, to which, if not to that of Cyrus, the oldest coins must be referred, from their style. The metals are gold and silver, the latter being that of the great bulk of the coinage. The form is usually flat and very thick. The types are of no great number. The main principle on which they were selected was a desire to honour the sovereign, which, if we recollect the worship the Achæmenian kings received, is not greatly different from the religious feeling of the Greek coinage. The chief observe-types represent the king in a chariot, sometimes hunting the lion, or as an archer drawing his bow. This personage is not, however, to be supposed in any case to be the reigning king, but rather the King of Persia in a kind of abstract sense. As a reverse to these types we notice occasionally a city or a galley. The money of the satraps is somewhat more Greek in its character, although it has among its types the representation of a king or satrap, that of a city, and the eastern device of a lion seizing a bull, and the like. The undoubted regal coins have generally no inscription whatever. Some, seemingly of this class, though they are perhaps of satraps, bear Phœnician characters, apparently the beginning of a name in one case, and in another, various dates. The coins of satraps have Phœnician inscriptions, usually giving the name of the person who issued the money, and that of the divinity of the place where it was struck. The art of this class of coins is not remarkable; it is at first similar to contemporary Greek art, and generally maintains, at least in some degree, its original conventional stiffness. There is one exception to this character in a beautiful coin attributed to Cyrus the Younger, to be soon mentioned, but this is in all respects a Greek piece, though evidently struck for a Persian king or usurper. The Persian coins are adjusted to the Phœnician talent. The principal denomination of the gold is the daric or daric stater. The chief silver coin is a third of the tetradrachm, a denomination which is not uncommon; and there are also octodrachms, as well as smaller pieces.

Coins of the Persian kings and satraps.

We will notice some of the principal coins, first of the kings, and then of the satraps, in chronological order, as far as this is practicable. The oldest Persian pieces are probably certain octodrachms of very early work. They bear on the obverse a galley beneath the walls of a town, and on the reverse the king in his chariot engaged in a lion-hunt. These can scarcely be later than the age of Cyrus or Cambyses; and it is most reasonable to suppose them to have been struck at Tyre. Next in time to these we would place the pieces with semi-Egyptian types, having on the one side an owl with a crook and flail, like the representations of Egyptian sacred hawks, and usually on the other a king or divinity riding upon a kind of sea-horse. The latter is sometimes the obverse-type. These we take to be the coins of Aryandes, satrap of Egypt, whom Herodotus relates to have been put to death by Darius Hystaspis for striking silver money; but they may perhaps be regal pieces. After these may be placed the gold darics and the silver pieces of the same type, and two-thirds of their weight, with the figure of the king, usually as an archer kneeling, on the obverse, and with an irregular incuse type on the reverse. These, or at least the gold coins, appear to have been current as late as the time of Artaxerxes Mnemon. To this reign we may assign, on strong evidence, a most remarkable coin, bearing the portrait of a Persian regal person on the obverse, and on the reverse a lyre, with the inscription ΒΑΣΙΛ. This is assigned by M. de Longpérier to Cyrus the Younger; and we accept his attribution as highly probable. Of the money of the satraps we may particularize the coins of Pharnabazus and Tiribazus, and those formerly attributed to Dernes, but given by Mr Waddington to the celebrated Datames. (The best work on the ancient Persian money is that of the Duc de Luynes on the coins of the satraps.[3])

Oriental Coins.

Parthian coins.

After eighty years of subjection, first to Alexander and his successors, and then to the earliest Bactrian kings, the Persian power was restored by Arsaces. With him the Parthian series of coins commences. This consists mainly of silver money, though there are also copper pieces. It shows markedly the influence of the Greeks, having inscriptions in their language, and its reverse-types derived from their coinage. The obverses bear the sovereigns' busts, which in the earlier period are often well executed. The denominations appear to be wholly of Greek origin. The Parthians were succeeded by the Sassanian princes. This line issued a more oriental coinage than their predecessors, bearing on the obverse the king's bust, usually wearing a very large and elaborate head-dress, and on the reverse the sacred fire-altar. The attachment which Ardeshir, the founder of this dynasty, bore towards the fire-worship, established this national reverse-type, which endured during the four hundred years that his house held the sovereignty. The Sassanian money is chiefly of silver; gold pieces are very rare. (On the Parthian coins the work of Mr Lindsay[4] should be consulted; on the Sassanian, M. de Longpérier's treatise.[5])

Sassanian coins.

Bactrian coins.

The Bactrian coins form an important link between the money of the West and that of the East. They were issued by the princes of one of the dynasties founded on the ruins of Alexander's empire, in so distant a territory that its very existence was scarcely known until the discovery of the coins. This kingdom was established B.C. 256, in the reign of Antiochus II., king of Syria, by the defection of Diodotus, governor of Bactria. The coinage of this first sovereign evidently follows that of the Seleucidæ in types and inscriptions, and, so far as the silver is concerned, in weight also; and the principal money of the subsequent rulers is of the same kind, although showing decay in its art. Under Agathocles, however, who seems to have been the successor of Diodotus, and certainly cannot have reigned much later, we observe the commencement of a peculiar class of coins, consisting of square copper pieces, bearing on the one side a Greek inscription, and on the other an Indian-Pali legend. The occurrence at this early period, in the midst of a Greek coinage, of pieces of a form unknown to the Greeks, and with an Indian as well as a Greek inscription, furnishes, as Mr Thomas argues, no weak evidence of an independent Indian coinage before this time—a subject to which we shall shortly recur. The Bactrian series is chiefly valuable from the aid it has afforded in the reconstruction of contemporary history. Much, however, remains to be done in the arrangement of the series before its full use can be realized. Of the coins of the successors of the kings already mentioned little need here be said, except that bilingual inscriptions become constant on silver as well as copper pieces, and that the former are sometimes of the square form. The Bactrian series is succeeded by more than one half-barbarous class similar to it, but far more oriental in character.

India.

The question of the independence of the earliest Indian coinage is of too complicated a nature to admit of its being here fully discussed, but we must indicate its main features in order to draw attention to a matter affecting ancient civilization in the far East. It must not be supposed, however, that the conclusion that the Indians had struck money before the time of Alexander, would attribute to them the separate invention of coinage: in this case it is more reasonable to presume that they had received Greek coins in commerce, and had thus been stimulated to issue a metal currency of their own. Mr Thomas has devoted much attention to this question, which will be found to be fully discussed in his edition of Prinsep's *Essays*. He argues on the existence of the square copper pieces in the Bactrian series, on the character of antiquity displayed by the Behát copper coins, and on the presumptive evidence of written records. The earliest class he considers to be that of silver

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[1] *Numismatique des Croisades*, par F. de Saulcy, 4to, Paris, 1847.

[2] *Numismata Orientalia Illustrata*, by W. Marsden, 4to, Lond., part i., 1823; part ii., 1825.

[3] *Essai sur la Numismatique des Satrapies et de la Phénicie, sous les Rois Achæménides*, par H. de Luynes, 4to, Paris, 1846, with plates in supplement.

[4] *A View of the History and Coinage of the Parthians*, by John Lindsay, 4to, Cork, 1852.

[5] *Essai sur les Médailles des Rois Perses de la Dynastie Sassanide*, par A. de Longpérier, 4to, Paris, 1840.

Oriental Coins.

punch-marked pieces. Of a later period than this whole class are the coins of the Sah kings of Saurâshtra, the age of which is far more nearly fixed. These are silver pieces bearing dates which show them to have been struck within about a hundred years. The dates Mr Thomas considers to be reckoned from the Sri Harsha Era, which would place the coins between the middle of the second and the middle of the first century B.C. The Sah kings were followed by the Guptas, who appear to have been at the first contemporary with them. To these belong the rude gold coins, with figures of Indian divinities, which are frequently found in the country. Their importance at the time, and their influence on the later coinage, must have been very great. The types of the later Hindu coins are of the same character as those of this group, although recently better executed. Although they are still issued, these proper Hindu coins have been long since virtually supplanted by those of the Mohammadan dynasties and the Company. (The most useful works on Bactrian and Indian money are Prinsep's *Numismatic Essays*, which have been collected and edited by Mr Thomas, and will be very shortly published. The original value of these papers is greatly enhanced by the labour and skill with which Mr Thomas has illustrated them, bringing them down to the present state of knowledge, and adding everywhere new information. Professor Wilson's *Ariana Antiqua*[1] must also be consulted. The most complete account, though one now requiring many additions, is in Marsden's great work, which we have already mentioned.)

Siam and China.

Beyond India, it may be mentioned that Siam has a coinage of its own, consisting of spherical lumps of silver, impressed with a punch, in the place of which coins with oriental types, but on a European model both in form and art, are now being issued. The Chinese money offers a field for great research. Here the question of an origin of money in the East, independently of Greek influence, is raised by the great antiquity that the Chinese writers assign to the commencement of the art among them. The conclusion, for the present at least, must here mainly depend upon our estimate of the value of the written evidence, for the money affords but doubtful testimony, more especially as the Chinese fabricate coins as they do vases, to deceive the curious. Some existing specimens are attributed to the twenty-first year (B.C. 523) of the reign of the Emperor King-wang, of the Tcheow Dynasty; but in the opinion of the Baron de Chaudoir, there is no certainty, before the reign of Chy-hoang-ty (B.C. 247-210), of the Heow-tsin Dynasty. The money consists almost wholly of copper pieces. These are at first of various shapes, sometimes being in the form of a sword or a bell, though flat; but at length they take the usual shape of coins, except that they are perforated in the centre with a square hole, in order that they may be strung. The silver coins are dollars of a recent period. The rebels have issued copper money resembling that of the Mantchoo Dynasty, but with their own inscriptions. (On the Chinese coins, Baron de Chaudoir's work should be consulted.[2])

Mohammadan coins.

The second class of oriental money—that of Mohammadan states—has been issued during a period extending from about the middle of the seventh century of the Christian Era to the present day. The oldest of positive date (gold coins) were struck A.H. 78. There are others, however (copper pieces), which must be ascribed to the interval between this date and the first great extension of Arab power, half a century earlier. We may mention the bilingual coins of cities of Syria and Palestine, Damascus, Emesa, and Tiberias, and barbarous imitations of the latest Byzantine money of Alexandria. Silver pieces are known of the year A.H. 79, but the dated copper coins do not commence until some years later: thenceforward the coinage of the greater number of Muslim states is in the three metals. The date of the earliest gold and silver coins thus falls into the reign of the Khaleefeh 'Abd-El-Melik Ibn-Marwán, under whom, in A.H. 76, the first Muslim coinage is related to have appeared, by El-Mekeen, Es-Suyootee, and Ibn Kuteybeh. There is a remarkable copper coin, generally resembling the bilingual pieces just mentioned, and having on one side a figure, probably representing the khaleefeh. In its inscriptions, which are wholly in Arabic, we read, "The servant of God (or 'Abd-Allah), 'Abd-El-Melik, the Prince of the Faithful."—The fabric and general appearance of the regular coins, especially for the first five centuries of their issue, is remarkably similar. They are always flat, and generally thin, and are without types, in the ordinary sense of the term, except some semi-barbarous ones, which originated in imitation of those of the current Byzantine money of the time, or of older Greek types. The whole of both sides of the coins is occupied by inscriptions, usually arranged horizontally in the areas, and in single or double bands around. With the rise of the Tatar power the old Arab type of the coins begins to be disused, and a new one introduced, mainly differing in the greater size of the pieces and the disposition of the inscriptions, which are placed in and around a square. This form was scarcely less wide in its use, or long in its duration, than that which it superseded. The prevalent metal of the earlier class is gold; of the later, silver. The intention of the inscriptions is religious. All Mohammadan coins bear the profession of the faith—"There is no deity but God: Mohammad is the apostle of God." The Shiya'ees add—"'Alee is the friend of God." The title of the khaleefeh, and afterwards his name also, or the name and title of the king, as well as the year of the Flight and the place of mintage, are generally given. The religious feeling as to the coinage was, until recent times, not less strong with the Muslims than with the ancient Greeks. For some centuries it was not lawful to put the name of any sovereign, as such, upon the coins, except that of the khaleefeh; and an independent prince, even if actually at war with him, continued to issue money in his name, doing no more than add his own, without any title, as though he were a provincial governor. The rival khaleefehs in Spain and Africa by degrees shook this privilege, and under the Turkish and Tatar dynasties it ceased, about the time when the khaleefehs of Baghdád had nearly lost all temporal power, shortly before their overthrow.

Oriental Coins.

Mohammadan coins cannot lay claim as a class to high artistic excellence. Their beauty depends, in the earlier period, upon the disposition of the inscriptions, and afterwards upon this combined with the form of the characters. Among the best of the older coins are those of the Umawee and 'Abbásee khaleefehs, and of the Fátimee khaleefehs in Egypt. The money of the Moors in Spain, of some of the later kings of Persia, and sultáns of Turkey, affords beautiful specimens of the more recent coinage. The finest, however, are generally inferior in execution, and often in design, to the best engraved work of the same times. The principal denominations, particularly during the earlier period, are well known. For many centuries there were scarcely any more pieces than one of each metal, the deenár of gold, the dirhem of silver, and the fels of copper,—and these were of nearly the same size, and otherwise very similar in their appearance. Their names betray a foreign origin; the deenár derived its appellation from the *denarius*; the dirhem, from the *drachma*; and the fels, from the *follis*. In its weight the deenár, at first of about 65·5 grains, followed that of the solidus, which at that time had succeeded to the aureus, and was doubtless the "piece of gold." The dirhem, of 45 grains, probably was considered as equivalent to the chief silver coin of the Isaurian family. The fels, however, cannot be readily identified, from the irregularity of the contemporary copper money of the Byzantines. At a later time, as the influence of the Eastern Empire wore out, the money of the commercial states of Italy affected the oriental coinages; and from this and other causes new systems took their rise, until in our own days the money of the Mohammadan dominions on the Mediterranean is generally assimilated to that of Christian Europe. (The most useful books on Mohammadan coins in general are, besides Marsden's *Numismata Orientalia*, the works of Frähn[3], Moller[4], and Erdmann.[5])

The coinage of the Umawee and 'Abbásee khaleefehs merits the same place in this series as the Byzantine in the mediæval. It presents little matter of historical interest beyond the indications of the condition of the state, from the abundance or the scantiness, or even the entire absence, of money under particular reigns. Thus we have evidence of the magnificence of the earliest princes of the house of El-'Abbás, and the misery of the latest, who yet held rule in the city of Baghdád, when the Tatar Hulágu was almost at its doors. Here and there the attention is fixed by a more definite fact, as when on the coins of Hároon Er-Rasheed we read the name of his famous wezeer Jaafar.

First among the Muslims of Africa and Western Europe we would place the khaleefehs of Spain, who in that remote country restored somewhat of the greatness of their ancestors of the house

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[1] *Ariana Antiqua, a Descriptive Account of the Antiquities and Coins of Afghanistan*, by H. H. Wilson, 4to, London, 1841.

[2] *Recueil de Monnaies de la Chine, du Japon*, &c., par le Baron S. de Chaudoir, fol., St Pétersbourg, 1842.

[3] *Ch. M. Frœhnii Recensio Numorum Muhammedanorum Acad. Imp. Scient. Petrop.* 4to, Petrop., 1826; *Ch. M. Frœhnii Nova Supplementa ad Recens.*, ed. B. Dorn, 4to, Petrop. 1855.

[4] *De Numis Orientalibus in Numophylacio Gothano Asservatis Commentatio Prima*, edit. alt., auctore J. H. Mœllero, 4to, Gothæ, 1826; *Commentatio Altera*, 4to, Erfordiæ et Gothæ, 1831.

[5] *Numi Asiatici Musei Universitatis, &c., Casanensis*, recensuit, &c., F. Erdmann, 2 vols. 4to, Casani, 1834.

Nun ‖ Nundinæ.

of Umeiyeh. Their money resembles that of the contemporary 'Abbásees. Under later dynasties, and especially that of the opulent and luxurious kings of Granada, large gold pieces were issued, noticeable for the fineness of their work. The coinage of the shereefs (or khaleefehs, as they have called themselves) of Morocco or Fez, of the Aghlabee Dynasty, and of the Fátimee khaleefehs at Keyrawán, before they had conquered Egypt, offers little to detain us. The money of Egypt itself forms a long series, well deserving of study. There is nothing remarkable of the period during which it was governed by the náibs or lieutenants of the Umawee and 'Abbásee khaleefehs, before the establishment of the independent dynasty of the Toolooneeyeh, A.D. 868. Of this house, and that of the Ikhsheedeeyeh, which succeeded it after a short interval, there are deenárs bearing the name of the reigning prince, besides that of the khaleefeh. The gold money of the Fátimee khaleefehs, who overthrew the line last mentioned, is well executed, and usually has two or three concentric inscriptions on each side. Under the Kurd or Eiyoobee Dynasty the coinage is similar; but under the two Memlook dynasties—the Turkish and the Circassian—the money is coarse, and rather resembles that of the Seljuks than the earlier series of Egypt. Since the Turkish conquest the money of this country has been similar to that of Constantinople, although possessing peculiar characteristics. In Syria there are coins of the Eiyoobee princes. Next to these we may place the money of the Seljuks and Turkuman Ortokites, the latter remarkable for the use of barbarous figures, derived from the Byzantine or ancient Greek types. The coins of the Atabegs form a group similar to the last. The money of the Turkish Empire shows the influence of the Italian republics. Its principal gold coin at the first was the *funduk*, of about 54 grains in weight, which was derived from the Venetian *sequin* or gold ducat, that, from the time of the decline of the credit of the Byzantine solidi, formed a principal coin of Western Asia. In recent times the money of the sultáns of Turkey is of elegant work, although generally not of pure metal.

Nundinæ.

The Persian coinage does not greatly differ from the contemporary money of the more western states. It may be said to commence under the powerful Samánee Dynasty, and to continue under the Soofees, and Nádir Shah and his successors. The most characteristic part of the coinage is the latest, in which we observe great beauty in the form of the letters and the ornaments, and an unusual variety of types. Among the latter may be noticed one of some gold coins of Fet-h 'Alee Shah, representing the king on horseback slaying a lion; and those of the copper pieces of uncertain date, one of which reproduces the ancient Persian device of the lion seizing the bull. The coins of the Mogul Tatars of Persia, of Teemoor, and of the Khans of Kapchak, resemble the contemporary Mohammadan coinage of other countries. The money of the Muslim dynasties of India forms a considerable class, although it must yield in importance to that of the Hindus. The chief series is that of the Patan or Afghán sultáns, and their successors the Mogul emperors. Among the minor groups we must notice the money of Tipoo Sultán, some of whose coins are very beautiful; and that of the kings of Oude, latterly remarkable for its grotesque imitation of modern heraldry. (This branch of Indian numismatics is treated of in the works before indicated as describing Mohammadan coins generally.) (R. S. P.)

NUN, or AKASSA, a river of Marocco, forming part of the southern boundary of that country. It rises in the Atlas range, and flows westward to the Atlantic, into which it discharges itself, 30 miles S.W. of Cape Nun, after a course of 130 miles.

NUN, or NON, a promontory of Marocco, in N. Lat. 28. 46., W. Long. 11. 3.

NUN, NONN, or NOMI, a river of the Chinese Empire, rises in Manchooria, flows generally southwards, forming part of the boundary between Manchooria and Mongolia, and falls into the Songari, an affluent of the Amur. Its length is about 600 miles, and its chief tributaries are the Hoojur, Noomin, Yalo, Tchola, and Toro.

NUNS, in the Roman Catholic Church, are female ascetics, who, like the monks of the other sex, retire from the world, form themselves into religious communities, and profess perpetual chastity. There are various orders of nuns; some devoting themselves entirely to private religious exercises, while others engage in the more active duties of Christian charity. The first nunnery is said to have been founded by one St Syncletica, a contemporary of St Anthony, in the third century. (See MONACHISM.) The first institution of the kind in France was founded near Poictiers by St Marcellina A.D. 360; and the first established in England owed its origin, according to Dugdale, to Edbald, king of Kent, who founded a nunnery at Folkestone A.D. 630.

NUNCIO (Lat. *nuntius*; It. *nunzio*) signifies a messenger in general, but is employed specially to designate the ambassador sent by the Pope to Roman Catholic states. This functionary is usually a prelate, and when a cardinal he is styled *legate*. In those countries subject to the decretals and discipline of the Council of Trent, the papal nuncios act as judges of appeal from the decision of the bishops; but in other Roman Catholic states (as France, Austria, &c.), which maintain their independency of the discipline of the Court of Rome, nuncios possess no jurisdiction, and have simply the diplomatic character of any other ambassador from a foreign court. In former times, however, the influence of nuncios and legates at foreign courts was frequently all but supreme.

NUNDINÆ, as if *Novemdinæ*, from *novem* and *dies*, signifying literally the ninth day, was the name given to the weekly market-days of Rome. The term was also occasionally extended to the place and business of these markets, as well as to the time at which they occurred. According to the ancient Calendaria, the entire year, beginning with the first of January, was divided into weeks of eight days each. Seven ordinary days would therefore always intervene between the last day of one week and the last day of the week immediately succeeding it. To these seven days, the Romans, after their customary mode of reckoning, added, not only the one immediately succeeding, but also the one immediately preceding, which made in all *nine* days, and hence they spoke of the market-day as occurring on the ninth day. A similar usage is still known in some countries where the expression "eight days" is frequently used for a week. Some affirm that the institution of the nundinæ owes its origin to Romulus, while others attribute it to Servius Tullius. As, however, the nundinæ were originally market-days for the country people, who, on these stated occasions, came to Rome to dispose of the produce of their labour, to provide themselves with necessaries, and to get their legal disputes adjusted by the king, it would seem to follow that the nundinæ must have originated at a time when the Roman population extended beyond the precincts of the city. The nundinæ were *dies nefasti* for the patricians, and *fasti* for the plebeians (Niebuhr's *Roman History*, vol. ii.); but when such a distinction arose does not appear, for, according to the ancient Calendaria, the nundinæ and *dies fasti*, or days of business, coincided. For the plebeians, however, the nundinæ continued to be business days, and on these they pled causes and held public meetings and debates with members of their own order on matters concerning the public or private interests of that order.

The Romans were always peculiarly careful lest the nundinæ should fall on the kalends of January, or on the nones of any month; and to avoid such an unfortunate conjunction, they were particularly watchful in the insertion of the *dies intercalaris*, or the 355th day of the Roman year. The *primæ kalendæ* were avoided, according to Macrobius, from the public belief that, if the nundinæ occurred then, the whole of the ensuing year would be signalized by misfortune; and the nones were shunned because the birth-day of Servius Tullius was celebrated on the nones of every month, and the presence of the country folk in the city on that occasion was deemed by the patri-

Nuneaton. Nunez

cians to be dangerous to the peace of the republic, owing to the excitability incidental to such a concourse of the plebeian order. Perhaps, however, more satisfactory grounds for this prejudice were to be found in the fact, that the kalends of January were observed as occasions of intimate domestic intercourse, and that the nones were believed to want the protection of the Deity.

NUNEATON, a market-town and parish of England, county of Warwick, on the left bank of the Anker, here crossed by two bridges, 14 miles N.W. of Rugby, and 17 N.N.E. of Warwick. It is well built, consisting of one main and several smaller streets. The parish church is a small but neat building, in the Gothic style, with a square tower. There are also places of worship for Independents, Wesleyans, Baptists, and Roman Catholics, as well as several schools. The chief manufacture is that of ribbons; but malting and silk-making are also carried on. In the neighbourhood are coal mines and stone quarries; and near the west of the town runs the Coventry Canal. The market-day is Saturday; and three yearly cattle fairs are held. Pop. (1851) 4859.

NUNEZ, or NONIUS, FERNANDO, an eminent classical editor, was born in the latter half of the fourteenth century at Valladolid, and was surnamed "El Pinciano," from *Pintia*, the ancient name of his native town. Though a scion of the noble family of Guzman, and a commander of the Order of Santiago, he consecrated his life to the pursuits of polite literature. After sitting at the feet of the eminent Antonio Lebrija, he studied for some time at Bologna, and returned to Spain the first Greek scholar of his age. His talents were soon employed, at the request of Cardinal Ximenes, in preparing the Latin version of the Septuagint for the Complutensian Polyglott. He was then installed by the same munificent patron of letters in the Greek chair of the newly-founded university of Alcalá de Henares. This office the force of circumstances induced him in course of time to abandon; and he was next appointed professor of rhetoric at Salamanca. It was there that those services in the cause of letters were chiefly performed which elicited the commendation of such men as Erasmus, Lipsius, and Vossius. The annotations that he published in 1536 on the works of Seneca restored the text of that author. He also produced *Observationes in Pomponium Melam*, 8vo, Salamanca, 1543; and *Observationes in Loca Obscura et Depravata Historiæ Naturalis C. Plinii*, Salamanca, 1544. At the same time, both from the academical chair and at his hospitable table, he was instructing many a young man that was destined to spread abroad the light of learning. He died in 1553, requesting that the following words might be inscribed on his tomb: *Maximum vitæ bonum mors*—("The greatest blessing in life is death").

NUNEZ, or *Nonius, Pedro*, an eminent Portuguese mathematician, was born at Alcacer do Sal in 1492. His attainments raised him to a high rank both as a teacher and as a writer in his own peculiar science. He became preceptor to Don Henry, son of King Emmanuel, and was installed in the mathematical chair at Coimbra. He also continued to publish, till his death in 1577, the following treatises:—*De Arte Navigandi; Annotationes in Theorias Planetarum Purbachii;* and *De Crepusculis.* It was in this last work that his device for subdividing the arcs of quadrants and other astronomical instruments was first promulgated. It consisted in describing within the same quadrant 45 concentric circles, and then dividing the outermost of these into 90 equal parts, the next into 89, the next into 88, and so on till the innermost, which is divided into 46. The *nonius*, as the instrument was called, was afterwards improved by others, until, in the hands of Pierre Vernier, it reached its present perfection, and received the name of the *vernier*. A collection of the works of Nuñez was published at Basle in 1592.

Nunez Nuremberg.

NUNEZ, or KAKUNDY, a river of Western Africa, in Senegambia, flowing westward, and falling into the Atlantic in N. Lat. 10. 40., W. Long. 14. 40. Its banks are thickly wooded, and very unhealthy. Some traffic is carried on in gold, ivory, hides, &c.

NUREMBERG (Germ. *Nürnberg*), a town of Bavaria, in the circle of Middle Franconia, stands on the Pegnitz, an affluent of the Regnitz, 95 miles N. by W. of Munich. It is built on both sides of the river, which is crossed by several bridges, on a sandy but fertile plain, about 1000 feet above the level of the sea; and from whatever side it is viewed, the towers of its churches present a very fine appearance. No other German town retains so much of the appearance and character of the middle ages; indeed, the principal feature of the town is the air of antiquity which pervades it. It is encircled by a high wall, from which rise numerous turrets, said to have formerly been 365, but now about 100 in number. Outside of the wall is a dry ditch, 50 feet deep and 100 broad, the sides of which are lined with masonry. The town is entered by four principal gates, which are flanked by large round watch-towers, no longer necessary for purposes of defence, but adding to the picturesque appearance of the place. The streets are narrow and irregular, lined with antique houses, having in general narrow but highly-ornamented fronts, and pointed gables fronting the street. The ground stories are low, and generally employed as warehouses; but the upper apartments, occupied as dwellings, are often richly adorned with carving and stucco, while many of the larger houses include two or three open courts. There are numerous public squares, of which the chief are—the principal market, in one corner of which is a fountain surmounted by a Gothic obelisk, with statues in stone; St Giles' Square, which contains a statue of Melancthon; and the Goose Market, adorned with a fountain and bronze image. The largest and finest church in Nuremberg is that of St Lawrence a Protestant place of worship, which stands on the south side of the river, and gives its name to that part of the town, as the church of St Sebald does to the other. It was built at the desire of the Emperor Adolphus of Nassau, in the thirteenth century, and has recently been completely restored. It is in the Gothic style, with two elegant towers surmounted by tapering spires. The portal at the west end is most profusely adorned with sculptures, and over it is a fine circular window 30 feet in diameter; while the interior is very rich in stained glass and ancient pictures. Its principal ornament, however, is a tabernacle, or repository for the sacramental wafer, a pyramidal erection of stone, 64 feet high, adorned with most exquisite carving. The church of St Sebald, though inferior to the former, is still one of the finest Gothic buildings in Germany, the west end being in the round style of the tenth century, while the towers, nave, and east end are of a later date, in the pointed style. The bronze shrine of St Sebald, the masterpiece of the celebrated Peter Vischer, who completed it, with the assistance of his sons, in 1519, after thirteen years' labour, is the chief object of interest here. It consists of a rich Gothic canopy supported by slender pillars, having beneath it the oaken coffin of the saint, adorned with silver plates; and although the church is now used for the Lutheran service, this magnificent monument is allowed to retain its place. The Catholic church, or *Frauenkirche*, was founded by the Emperor Charles IV., and completed in 1361, in the best style of German-Gothic architecture. It contains many ancient monuments, and a complicated clock, which shows the movements of the sun and moon. Besides these, there is also a Gothic chapel, dedicated to St Maurice, which is now used as a picture gallery. The town-hall, a building in the Italian style, erected in 1619, contains

Nurpoor ‖ Nursia.

within it an older portion, built in 1340. The great hall, which is 76 feet long and 28 wide, is adorned with paintings by Albert Dürer; and there is a smaller council-chamber above. Underneath the building there are dismal dungeons and a torture-chamber; and subterranean passages have recently been discovered leading beneath the city to the town ditch. To the north of the town, on a sandstone rock, stands the castle, built in 1030 by the Emperor Conrad II., and presented by the town in 1855 to the king. It is now used as a royal palace; and contains a linden tree, said to have been planted by Queen Kunigunda 700 years ago. Nuremberg has a grammar school, founded by Melancthon, whose statue adorns its front; a public library, with 30,000 volumes; a school of design; polytechnic, industrial, and other schools; a theatre; a general and a military hospital; a deaf-and-dumb asylum; orphan hospital; and other benevolent institutions. There are also several scientific societies. The churchyard of St John, about half a mile to the N.W. of the town, is remarkable as having been the burial-place for several centuries of the aristocracy of Nuremberg. It contains 3500 grave-stones, all regularly numbered, and most of them adorned with the armorial bearings of the dead. Between this and the city gate stand seven stone pillars, with sculptures representing scenes in the passion of our Saviour. Nuremberg is at present the most important manufacturing and commercial town in Bavaria. Cloth, brass, bronze, and steel-ware, wires, needles, musical and mathematical instruments, toys, and black-lead pencils are the principal articles made; and in these an extensive trade is carried on, as this place is the chief mart for goods passing between the north and the south of Europe. It was formerly a much more important city, and in the middle ages rose to a great height in wealth and prosperity. The earliest mention of the town is about the middle of the eleventh century, when it received from Henry III. the privileges of a free market, and the right of coining money and levying toll. From this time it steadily increased in wealth and population, and obtained further privileges from subsequent emperors. In 1219 it was made a free city, independent of any European power; and as such it continued till it was given over by Napoleon in 1806 to the King of Bavaria. The period of its highest prosperity was during the fifteenth and sixteenth centuries, when it was able to furnish 6000 men to the imperial army. But the discovery of the passage to India by the Cape of Good Hope, by directing the commerce with the East into a different channel, led to the decline of Nuremberg as a place of trade; and though it has recently again risen in importance, it has never regained its mediæval prosperity. At the Reformation the inhabitants early embraced the Protestant cause; and in the Thirty Years' War they were on the side of the Swedes, and suffered much in 1632, during the blockade which Gustavus Adolphus endured from the imperial forces under Wallenstein. Nuremberg was the birthplace of many remarkable men, among whom the most distinguished is Albert Dürer the painter, whose house is still to be seen. Pop. (1843) 45,381; (1855) about 50,000.

NURPOOR, a town of British India, in the Baree Dooab division of the Punjab, on a small affluent of the Ravee, among the lower mountains of the Himalaya chain; N. Lat. 32. 18., E. Long. 75. 57. A large proportion of the inhabitants are Cashmerians, who are employed in the weaving of shawls. The town has a large and well-supplied bazaar; and derives much importance from its position on the route between India and Cashmere. It was originally governed by a hereditary rajah, but was afterwards seized by the Sikhs. There is a fort of stones and mud, on an eminence 200 feet high, but it is commanded by the higher elevations which surround it. Pop. 6000 or 8000.

NURSIA, an ancient city of the Sabines, situated at the foot of that lofty group of the Apennine range now known as the Monti della Sibilla. From the nature of its position, in the immediate vicinity of high mountains, the climate of Nursia was somewhat cold. Virgil alludes to it as *Nursia frigida* (*Æn.* vii. 716), and Silius Italicus (viii. 417) does the same. It is mentioned by Livy (xxviii. 45) as furnishing volunteers for the armies of Scipio during the second Punic war, about two centuries before the Christian era. At this period it must have been one of the most important towns of the Sabines, as it is mentioned in the same connection as Reate and Amiternum. Under the Romans it held the rank of a municipal town, and seems to have been somewhat republican in its sympathies; for we find its inhabitants chastised by Octavian for their adherence to the cause of the democratic party. Columella (x. 421) and Pliny (xviii. 13, § 34) allude to the *rapa Nursina*, or Nursian turnips, as having been celebrated in their day; and Martial (xiii. 20) refers to the same circumstance when he speaks of the *pilæ Nursinæ*. From its secluded position, this town is not mentioned in the Roman Itineraries. It gave birth, however, to Vespasia Polla, the mother of the Emperor Vespasian; and at a place called Vespasiæ, not many miles from Nursia, the monuments of this distinguished family were to be seen during the time of Suetonius. It is perhaps more celebrated still as the birth-place of the famous Benedict of Nursia, the founder of the first great monastic order in the Christian church. The place had been made an episcopal see at a very early period, and is said to have had St Eutychius for its first bishop. Massive walls are said to be seen still at *Norcia*, resembling those of the Sabine towns of Reate and Amiternum. These ruins form the only traces of this old Etruscan town.

Nurtingen. ‖ Nutmeg.

NURTINGEN, a town of Würtemberg, circle of Schwarzwald, on the Neckar, 14 miles S.S.E. of Stuttgardt. It contains an old castle, a church, a rich hospital founded in 1480, and several schools. There are also cotton factories, dye-works, and manufactories of musical instruments. Pop. 4550.

NUSSEERABAD, a cantonment of British India, in the district of Ajmeer, North-West Provinces, stands on a large sandy plain, 15 miles S.E. of Ajmeer; N. Lat. 26. 20., E. Lon. 74. 50. It is large, and regularly laid out, with broad streets, and has several tanks and wells. The climate is considered superior to that of any other station in India; but the heat is very great, sometimes in summer rising above 100°. The mean annual temperature is about 76°.

NUTMEG, the kernel of the fruit of *Myristica fragrans*, Houttuyn (Nat. Ord. *Myristicaceæ*), and two or three other species of the same genus. The common nutmeg tree grows from 20 to 25 feet in height, and is very handsome in form and habit. The fruit, which is abundantly produced, resembles the peach in colour, but is rather pear-like in shape. This fruit consists of four parts. The outermost is a thick fleshy pericarp, which has a strong flavour of nutmeg. This portion is not generally used, but is occasionally preserved in syrup as a sweetmeat. The next portion is the curious scarlet mesocarp or arillode, called *mace*. This incloses the endocarp, which is a thin and brittle shell of a shining brown colour, furrowed longitudinally by the pressure of the mace, and within this shell is the *kernel*, or nutmeg. Nutmegs are imported from Penang and other Indian islands. The quantity imported in 1856 was 468,501 lb., of which a considerable quantity was again exported to other countries. Nutmegs are packed in very strong chests, and are usually powdered with lime, to prevent the attack of a weevil-like insect, the *Arœocerus coffeæ*, which is very destructive, often destroying the entire contents of a chest (about 2½ cwt.), of the value ofL. 35. Besides the common nutmeg, a sort called the *long*, or *wild nutmeg*, is frequently imported. It is usually inclosed in the shell, and is nearly twice as long as

Nutrition ‖ Nuts.

the common nutmeg, but not any thicker. This is the fruit of *Myristica fatua*, Houttuyn. It is brought from the Banda Isles, and is inferior to the common nutmeg. The nutmeg yields, by expression, a solid yellow fat, called *oil of mace*, or *butter of nutmegs*, which is sometimes used in pharmacy. (See Oils.) The duty on nutmegs is one shilling per pound. (T. C. A.)

NUTRITION. See Food, and Dietetics.

NUTS. The term nut is applied to that class of fruits which consist generally of a single kernel inclosed in a hard shell. Botanically speaking, they are one-celled fruits with hardened pericarps, more or less enveloped in a cupule or cup, formed by the aggregation of the bracts. Several nuts are of considerable importance, in consequence of their sweet edible kernels, and some from their abundant oil.

The common *Hazel-nut* of the shops, or the *small nut* of our import tariff, is the fruit of the hazel (*Corylus avellana*, W.) The hazel-nut is now found generally throughout the temperate parts of Europe and in many parts of Asia. In Spain, Sicily, and some parts of Turkey, it is very extensively cultivated, and forms an important article of trade. The import of hazel-nuts to this country alone is immense. In 1857 it was about 224,486 bushels, of which the chief part came from Spain, and the remainder from Sicily, Smyrna, and Constantinople. From Spain we receive two principal kinds, but they appear to differ only in the circumstance that the so-called *Barcelona* nut is kiln-dried, whereas the Black Spanish is the fresh ripe nut. The latter is only sent at the commencement of the season, as it will not keep long. They are usually sent in bags of two bushels each; but it not unfrequently happens that they are imported in bulk, especially from Smyrna, whence we receive the small red nut (*Corylus Colurna*, Willd.) Besides its extensive use as an edible fruit, the hazel-nut yields an oil which is much valued by artists in oil-colours and by watchmakers. (See Oils.) The filbert is extensively cultivated in England, particularly in Kent; and the common hazel is one of the commonest of our coppice shrubs. The *Walnut* is the fruit of *Juglans regia*, Linn. (Nat. Ord. *Juglandaceæ*), and is found in the northern parts of Asia. It seems probable that the nuts mentioned in Genesis xliii. 11, were walnuts, as Pliny says the native country of the nut is Pontus, and vast quantities are still gathered in the neighbourhood of Trebizond. He mentions two kinds, both of which were occasionally eaten roasted, viz., the *Abellina* (*C. avellana*, W.), so named from Abellinum in Campania; and another kind, which is supposed to have been the filbert (*C. tubulosa*, W.) The walnut tree is now cultivated generally throughout Europe, and is as much valued for the fine timber it produces as for its edible nuts. In this country the young green nuts, before the shells become hard, are gathered in considerable quantities and made into a favourite pickle. The nuts are imported from Germany, Italy, France, and Spain, and sometimes from Turkey: 57,000 bushels were imported from these places in 1857. They are only used in this country as an eatable fruit; but in Cashmere they are pressed for oil in great quantities. The *Hog-nut* (*Juglans porcina*, Michaux), and the *Black walnut* (*Juglans nigra*, Linn.), natives of Canada, are occasionally brought in small quantities from that country, and are sometimes seen in our fruiterers' shops, but are inferior to the common walnut. Two other nuts, closely allied to the walnut in the same natural order, are the *Hickory-nut* (*Carya alba*, Nuttall), with which are often mixed the nuts of *C. sulcata*, Nutt., now frequently brought from the United States. These, however, are so much alike that they are not ordinarily recognised as distinct from each other. They are smaller than the walnut, have smooth hard shells of a light colour, resembling common deal-wood, are marked by longitudinal ridges, and do not split into two shells. The *Peccan-nut* (*Carya oliviæformis*, Nuttall), usually imported from New Orleans, is nearly of the shape and size of the olive, but somewhat longer and thinner. The shell of this favourite nut is very thin and smooth, and the kernel plump and large. The quantity of hickory and peccan nuts annually imported is small, probably not exceeding 800 bushels; but it cannot be ascertained with certainty, as the greater part received is in the form of presents. They are, however, beginning to be in demand in our markets. The *Chestnut* is produced by a large tree (*Castanea vesca*, Gaertner), Nat. Ord. *Corylaceæ*. The tree takes its name from Castana in Thessaly, but is so commonly distributed over Europe that it is probably indigenous to most of the southern countries of that continent. It is very abundant in Spain, whence we receive the greater part of the chestnuts brought to this country. It was well known to the Romans; and Pliny speaks of eighteen varieties of this fruit. He says it was called by the Greeks *Dios balanon*, or "Jove's acorn," and Sardian acorn, from its having been first introduced by the people called Sardes. In his day the choice sorts were roasted and eaten, and the inferior ones used for feeding pigs. Of late, limited quantities of small sweet chestnuts have been imported from the United States, which are probably the fruit of *Castanea vesca*, naturalized in America. The quantity of chestnuts imported from Spain and other parts in 1857 was 84,000 bushels. The *Brazil-nut*, or Juvia, is the fruit of one of the largest trees of the Brazilian forests, the *Bertholletia excelsa*, Humboldt and Bonpland (Nat. Ord. *Lecythidaceæ*). This nut, which is also called Para-nut and Castanha-nut, is at first inclosed in an outer apple-shaped shell as large as a moderate-sized melon. This usually contains about twenty of the nuts, which average an inch and a half in length, and are thick and triangular in the middle, but sharp at each end, with a rough greyish-brown shell. The kernel is very sweet and oily. They are imported chiefly from the ports of Para and Maranham, generally in bulk. The import for 1857 was 27,000 bushels. The *Sapucaia-nut*, another Brazilian fruit, is also seen occasionally in our fruit shops. It is produced by a large tree of the same natural order as the Bertholletia, called *Lecythis ollaria*, or "Cannon-ball tree." Its specific name is taken from the large urn-shaped capsules, called "monkey-pots" by the inhabitants, which contain the nuts. The Sapucaia-nut has a sweet flavour, resembling the almond, and if better known would be highly appreciated. They are, however, scarce, as the monkeys and other wild animals are said to be particularly fond of them. This nut, which is of a rich amber-brown, is not unlike the Brazil-nut, but it has a smooth shell furrowed with deep longitudinal wrinkles. The Sapucaia-nut has hitherto only been imported into Liverpool; and the whole quantity is not more than forty or fifty bushels per annum. The *Pistachio-nut* is the fruit of *Pistacia vera*, Linn. (Nat. Ord. *Anacardiaceæ*). It is a native of Syria. Although a remarkably delicious nut, and much prized by the Greeks and other eastern nations, it is not well known in this country. It is not so large as a hazel-nut, but is rather longer and much thinner, and the shell is covered with a somewhat wrinkled skin. The quantity imported is very small and uncertain. The small nut of *Pistacia lentiscus*, Linn., not larger than a cherry-stone, is also occasionally imported from Smyrna, Constantinople, and Greece. The *Cashew-nut* belongs to the same natural order as the *Pistachio*. It is the fruit of a small tree, the *Anacardium occidentale*, a few bushels of which are occasionally sent from the West Indies, where it is a native. The *Cajou* or *Cashew nut* is remarkable in consequence of the enlargement of the receptacle or peduncle after the flower falls. This receptacle, on the top of which the nut grows, becomes as large as a good-sized pear, and is sweet and agreeable to the taste. The *Souari* or *Surahwa nut*, called also the "Butter-nut of Demerary," and by our fruiterers the "Suwarrow-nut," is the fruit of *Caryocar butyrosum*, Willd. (Nat. Ord. *Rhizobolaceæ*),—the *Pèkea butyrôsa* of Aublett, a native of the forests of Guyana, growing 80 feet in height. This is perhaps the finest of all the fruits called nuts. The kernel is large, soft, and even sweeter than the almond, which it somewhat resembles in taste. The few that are imported come from Demerary, and are about the size of an egg, somewhat kidney-shaped, of a rich reddish-brown colour, and covered with large rounded tubercles. The *Cocoa-nut* is the fruit of *Cocos nucifera* (Nat. Ord. *Palmaceæ*). This nut is, when ripe, inclosed in a large fibrous husky shell, which yields the vegetable fibre called *coir*. The kernel forms an inner coating to the hard shell, about three-quarters of an inch thick, inclosing at first a sweet limpid liquid, called the milk, which afterwards becomes the albumen of the seed. It is the inner fleshy portion of the kernel which is eaten. In the tropics it is universally regarded as a very wholesome and nutritious fruit, and yields a large quantity of oil. (See Oils.) Cocoa-nuts are imported from the West Indies, and sometimes from Western Africa. About a million and a half are received annually. *Ground-nuts* are the fruits of *Arachis hypogæa* Linn. (Nat. Ord. *Leguminosæ*). They are roundish, irregular-shaped pods, improperly called nuts, of a straw colour, covered with small square depressions, arranged with considerable regularity. They contain two or three reddish-brown seeds, which have the flavour of the gray field-pea. They are sometimes eaten when roasted, but are chiefly used for expressing oils. (See Oils.) They are sometimes imported in large quantities from Africa and the West Indies. It is said to be a native of South America, but there is reason to believe it came originally from Africa. (T. C. A.)

Nux Vomica.

NUX VOMICA, the seeds of a moderate-sized tree, *Strychnos Nux-Vomica*, Linn. (Nat. Ord. *Loganiaceæ*, Div. *Strychneæ*), a native of the coast of Coromandel. The nux vomica, or poison-nut, has been known for a long time, and is supposed to have been made known to Europe by the Arabian physicians; but one or two other seeds have evi-

Nyassi ‖ Nyiregyhaza.

dently been confounded with it. The pulpy fruit which incloses the seed is about the size of an orange, with a thin brittle shell, of a brilliant orange colour; and, from the fact that the pulp is eaten by birds, would seem to be innocuous. The fruit contains many seeds, imbedded in a white gelatinous pulp. These seeds are about three-fourths of an inch in diameter, quite circular, slightly convex on one side, and depressed on the other; of a peculiar silky appearance, and of a light-drab colour, not unlike silk-covered buttons. They are very hard and horny, and consist chiefly of dark greenish-gray albumen, in which their intensely poisonous quality resides. The deadly powers of this seed are due to the presence of the alkaloid called strychnia or strychnine, a salt consisting of C_{44} H_{24} N_2 O_8; but it contains another poisonous alkaloid called brucine, of nearly similar composition—C_{44} H_{25} N_2 O_7. It was discovered in 1818 by Pelletier and Caventou, and it was afterwards proved by M. Magendie and by Dr Fouquier that the salt possessed a remarkable specific action upon the spinal marrow without particularly affecting the brain. It has consequently been found very serviceable in certain spinal diseases, but its administration requires excessive care. Almost every part of the tree, except the pulp of the fruit, partakes of the intense bitter of the seed. The poisonous bark introduced into Europe as angostura bark did not come from South America, but from India, and proves to be that of the *S. nux-vomica*. The wood is very hard, and is used as a useful kind of timber. The imports of nux vomica were only 550 lb. in 1840; but in 1857 it was over 1000 bags, or about 250 cwt. The use to which this large quantity of so powerful a poison is applied is by no means clear. Much is employed for the destruction of rats and other noxious animals, but not sufficient to account for so great an increase. It is free of duty, and is almost always imported from Bombay in small bags of about 28 lb. each, and is worth from 6s. to 8s. per cwt. (T. C. A.)

NYASSI, or *The Sea*, a lake in the interior of equatorial Africa, has been known by report to Europeans for about three centuries, but has never yet been reached or explored by them. The latitude of its centre is about 10. S., and it is believed to extend from S.E. to N.W. between E. Long. 30. and 35. It is known by various names, and appears to be the same as the lake called Maravi on old maps. The great rivers Nile, Zaire, and Zambesi have been supposed to take their source from this lake, but the truth of the statement is more than doubtful.

NYIREGYHAZA, a market-town of Upper Hungary, in the county of Szabolcs, 29 miles N. of Debreczin. It has a Greek, a Roman Catholic, and two Protestant churches; a Protestant school; saltpetre-works; and mineral springs. A yearly market of considerable importance is held here. Pop. (1851) 13,826, mostly Protestants.

Nyköping. ‖ Nymphs.

NYKÖPING, a seaport-town of Sweden, capital of a län of the same name, stands on an inlet of the Baltic, 54 miles S.W. of Stockholm. It is regularly built, and contains a new and an old castle, several courts and public offices, three churches, an hospital, and manufactories of linen, cotton, and woollen stuffs, hosiery, tobacco, needles, &c. Pop. 3486. The län is bounded on the N. by Lake Mälar, which separates it from Upsala and Westeras, E. by Stockholm and the Baltic, S. by Linköping, and W. by Orebro. Area 2497 square miles. Many valuable minerals, such as iron, copper, lead, &c., are obtained here: the higher regions are well wooded, and the plains fertile and well cultivated. The bays on the Baltic coast facilitate the exportation of metals, timber, corn, and cattle. Pop. (1850) 120,113.

NYMPHS (Gr. *νύμφαι*, Lat. *nymphæ*), in Greek and Roman mythology, a class of inferior female deities of almost infinite number, who were held to preside over all parts of the earth. They were commonly represented as beautiful young women, and generally in the train of some of the greater divinities, such as Neptune, Juno, Diana, or Pan. In most parts of Greece and Italy they were worshipped with offerings of kids, lambs, milk, or honey, but never of wine. In the latter country they were sometimes honoured with special temples or chapels. The interest they took in men and human affairs was believed to be entirely of a kindly and beneficent nature. They presided alike over the dry land and the watery element. In the former class the most important were the mountain nymphs, the *Oreades* or *Orodemniades*, who also took local names from the special hills which they haunted, such as *Cithæronides*, &c.; the nymphs of trees, the *Dryades* and *Hamadryades*, whose life was commensurate with that of the forest tree in which they had their abode; and the nymphs of valleys and groves, the *Napææ*, &c. Of the water-nymphs the most important were the *Oceanides*, the daughters of Oceanus and Tethys, said to be 3000 in number. After them may be named the *Nereids*, the daughters of Nereus and Doris, fifty in number, of whom the most famous were Amphitrite, the wife of Neptune; Thetis, the mother of Achilles; Galatea, &c. Their favourite haunt was the Ægean Sea, and they were held in high honour throughout Greece, especially at Corinth. The river-nymphs, the *Potameides*, were worshipped under local names, derived from the special rivers over which they presided; such as *Acheloides*, from the Achelous; *Pactolides*, from the Pactolus, &c. The *Naiades*, or nymphs of the fresh water, were known as *Limnades* and *Crenææ*, or *Pegææ*, according as they inhabited lakes or springs. Even the waters of Hades had their presiding nymphs, the *Avernales*, many of whom were believed to be endowed with prophetic power, and to communicate that gift to their favourites among men.

O.

O
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Oases.

O, the fifteenth letter and the fourth vowel of the English alphabet, occupies a position in point of sound between the vowels *a* and *u*. The shape of the letter seems to have originated in the circular form assumed by the lips in pronouncing it; yet in the hieroglyphical characters, and even in the ancient Greek alphabet, it appears to have been taken from the shape of the eye. In English O has a long sound, as in *bone, moan, broke, roll*, which is usually denoted in a word or syllable by a final *e*, as in *bone, lonely*, or by a servile *a* as in *moan, roaming*. It has also a short sound as in *hot, long*, and a soft sound like the Italian *u* and the French *ou*, as in *move*, which is shortened in words ending in a close articulation, and represented by *oo* as in *look, root*. The vowel *o* is convertible with a variety of vowels and of vowel combinations, in English, as well as in other languages; *e.g.*, what is *o* to the eye is *u* to the ear in the words *son, none, done, won*. The English *o* in the words *one, two, gone* becomes *a* in Scotch as *ane, twa, gane;* and *o* interchanges with *ea* in *cleave, clove; heat, hot*, &c. O was used as a numeral by the ancients to represent 11, and with a dash over it ($\overline{O}$) to denote 11,000. Among the Irish O prefixed to proper names, like *Fitz* in England and *Mac* in Scotland, signifies *son of*, as O'Neal, the *son of* Neal; and was originally employed as a character of family dignity. O, a circle, or CO is called by the Italians *circolo*, and is used by them to express *tempo perfetto* in music, or what we call triple time. (For the use of O in abbreviations, see ABBREVIATIONS.) O is often employed as an interjection to express a wish, admiration, pity, surprise, &c.; but when strong emotion is to be conveyed, the exclamation is written Oh!

OAK. See PLANTING, TIMBER, and SHIP-BUILDING.

OAKHAM, or OKEHAM, a market-town of England, capital of the county of Rutland, stands in the fertile vale of Catmore, 17 miles E. by N. of Leicester, and 85 N.N.W. of London. It is pretty well built; and contains an old castle supposed to have been built in the reign of Henry II., and now used as a county-hall; an ancient parish church, with a lofty spire; Presbyterian, Independent, Wesleyan, and Baptist places of worship; national schools; and a free grammar school, founded in 1584, with an hospital for old men attached to it. The chief manufacture is that of silk shag for hats. Oakham is not commercially of much importance; and, though some traffic in coals is carried on, it depends principally on its retail trade in articles of home use. There is a canal between this place and Melton-Mowbray. Several yearly fairs for cattle and sheep are held here. Pop. (1851) 2800.

OASES was the name given by ancient writers to the verdant spots that occur at intervals in the midst of the waste sands of Africa, and is said to be derived from the Coptic word *ouah*, a resting-place. The foundation of an oasis is a hollow stratum of sandstone or clay, which retains the moisture that flows into it, and which is encircled by a rim of the limestone that forms the bed of the surrounding desert. On this basis springs up in green luxuriance an orchard of date, fruit, and other trees, interspersed with wheat and millet. These oases, as the etymology given above implies, seem to have been originally used merely as halting-places for the Egyptian and Ethiopian traders in their journey through the desert. It was not until the Persian conquest of Egypt that they became permanent settlements. They were afterwards garrisoned by the Greeks and Romans in succession; and at a still later period they became a place of refuge, first to persecuted Christians, and then to heretics. Their number was great. Herodotus likens them to a chain stretching from E. to W. through the Libyan desert. But the most celebrated were four, called respectively Oasis Magna, Oasis Trinytheos, Oasis Minor, and Ammonium. The Oasis Magna (the modern *El-Khargeh*) is about 90 miles W. from the banks of the Nile, and is 80 miles in length, and from 8 to 10 in breadth. It was a district of great importance in ancient times. Herodotus called it the "City Oasis;" and Josephus called it "The Oasis" *par excellence*. In pagan times it was the site of a temple 468 feet long, and dedicated to Amûn-Ra; and after the commencement of the Christian era it was crowded with churches and monasteries. The Oasis Trinytheos (the modern *El-Bacharieh*) was situated N. from the Oasis Magna, and W. from the city of Hermopolis Magna. There is no evidence that it was ever a permanent settlement of the Egyptians, the Persians, or the Greeks. The most ancient architectural remains are Roman. The fact, however, that several Artesian wells have been recently discovered there, and that the construction of these was unknown to the nations above mentioned, seems to indicate that the Oasis Trinytheos was visited at an early period by some people who had imported the art of making artificial springs from the eastern countries of Asia. The Oasis Minor (the modern *El-Dakkel*) was situated nearly N. fron the Oasis Magna, and W. from the city of Oxyrynchus. The ruins of a temple and several tombs show that it was a station of the Greeks. It was also under the dominion of the Romans, and was then famous for its wheat. Ammonium (the modern *El-Siwah*) was situated N.W. from the Oasis Minor. Though not more than 6 miles in length and 3 in breadth, it was at one time the most famous of all the oases. Its soil produced salt in great abundance and of the finest quality, and at the same time was well watered and fruitful. There also was the celebrated "Fountain of the Sun" which Herodotus saw in the fifth century B.C. There especially was the temple of Jupiter Ammon, which Alexander the Great visited in 331 B.C., and which was built of stone, of a blue and green colour, and covered with hieroglyphics. The fountain is still seen springing up in a grove of dates; and the walls of the temple, retaining their bright colouring, are still seen in ruins near the village of Gharmy.

The term *oasis* has in modern times come to signify any fertile tract in the midst of a desert.

Oates.

OATES, TITUS, the infamous fabricator of the "Popish Plot," was born about 1619. From the very first he was an apostate and a deceiver. He left the Anabaptists, among whom he had been trained, and after studying at Cambridge, accepted a benefice in the Church of England. With this position his life and opinions were soon found to be glaringly inconsistent; and he entered a Jesuit college in France. Even there his conduct was too unprincipled to be endured; and in 1677 he found himself obliged to take up the profession of a scheming vagabond. It was then that Oates, animated probably by the hope of gain and the love of low intrigue, resolved to take advantage of the alarm into which the English nation had been thrown on account of the suspected Popish inclinations of Charles II., the avowed Popish opinions of the Duke of York, and the growing confidence of the Papists in general. He patched up a chimerical story, and communicated it to the government at London as a plot which had been formed by the Roman Catholics. The capital, he said, was to be set on fire, the citizens massacred, the king assassinated, Ireland invaded by a French army, and certain Papists whom he named placed in the high offices of the state. This fabri-

Oaths.

cation realizing the apprehensions in the public mind, and seeming to be corroborated by certain events, gained universal credence. The government were at their wits' end; all London was instantly on the alert for the expected attack; and the people, hurried on by the blind instincts of hatred to their foes and gratitude to their supposed saviour, rushed into an extreme course of action. Oates was raised to the summit of popularity and power; a pension of L.900 a year was conferred upon him; nothing less magnificent than a suite of apartments in Whitehall Palace was thought worthy of lodging his precious person; and whenever he appeared in public he was greeted by the unbonneted populace. The fresh fictions which he continued to invent regarding the plot were also received without hesitation. With the aid of certain worthless associates, he procured the conviction of many innocent Roman Catholics, and was the main cause of a series of judicial murders which extended over the space of two years. By that time, however, the nation was opening its eyes upon the monstrous system of deceit by which it had been duped, and a storm of retribution was gathering against the head of the arch offender. On the accession of James II. in 1685, he was tried before the Court of King's Bench, was convicted of perjury, and was sentenced to be first pilloried and whipt at the cart's tail, and then to be imprisoned for life. The former part of the punishment was executed with a severity which was evidently intended to kill him. The latter part was broken off by the accession of William III., and the simultaneous re-action in the state of public feeling. The trial of Oates was then declared by Parliament to have been illegal; his crimes were pardoned by the king; and he was allowed to skulk away into obscurity with a pension of L.300 a-year. He died in 1705. (For the particulars of the "Popish Plot," see BRITAIN. See also Lord Macaulay's *History of England*.)

OATHS are solemn declarations made, with an appeal to God or to some superior being, for the truth of what is affirmed, or for the honesty of what is promised. It is always to be presumed, in the taking of an oath, that the person imposing it believes that the swearer expects the superior being whom he calls to witness will visit him with punishment in the event of his violating that oath. On no other supposition can an oath be conceived of any value or significance. The person making the oath may or may not fear the evil consequences of perjury; but the individual imposing the oath is supposed to believe that the swearer is apprehensive of those consequences. Oaths are *assertory*, or those by which something is affirmed as true; and *promissory*, or those by which something is promised to be done. Oaths are again either voluntary or compulsory.

Jewish oaths.

It would appear, from all that can be gathered on the subject, that the practice of using oaths on certain important occasions has been observed in all nations where any definite idea of a superior being has prevailed. This practice is found as early as the days of Abraham, who charges his servant: "Put, I pray thee, thy hand under my thigh; and I will make thee swear by the Lord, the God of heaven and the God of earth, that," &c. (Gen. xxiv. 2, 3, 37). This oath was private rather than judicial or national. Instances of public or national oaths, in which an entire kingdom or a large body of people were involved, are to be found in Judges xxi.; also in 1 Kings xviii. 10; and the first example of a strictly judicial oath is to be found in Levit. vi. 3-5. This custom of oath-making, which had been in use amongst the Jews from the earliest times, was sanctioned by Moses, and employed by him in connection with his code of laws. Other beings besides God were sometimes invoked in taking an oath, among the Hebrews and certain other nations of the East; as the soul (2 Kings ii. 2; 1 Sam. xx. 3, &c.); the head or life of a king (Gen. xlii. 15). The most solemn oath among the Persians, according to Hanway, is, "By the king's head;" and Aben Ezra informs us that this oath was common in Egypt in his time (A.D. 1170) among the khaliphs. Sometimes the oath-taker swore by some precious part of his own body, as the head (Matt. v. 36); by the earth, the heaven, and the sun (Matt. v. 34, 35); by angels (Josephus, *De Bell. Jud.* ii. 16, 4); by the temple (Matt. xxiii. 16); and by Jerusalem (Matt. v. 35; compare *Lightfoot*, p. 281). The levity of the Jewish nation with regard to oaths became notorious; and while we find some of their doctors sharply reproving this vice (Othon. *Lex.*, p. 351; Philo, ii. 194), it is nevertheless notorious that the rabbinical writers, by their nice distinctions, subtle casuistry, and perverse ingenuity on the subject of swearing, did much in effect to countenance open falsehood, and lessen the enormities of perjury and profanation. The heathen satirists poisoned their shafts against the Jew with the blasphemous perjury of that race (Martial, xi. 9); and when we come down to Christian times, we find a growing disposition to discountenance a practice which had been prostituted to the worst of purposes. Some contend that the language of Christ respecting oaths (Matt. v. 34-37) is absolutely prohibitory of that practice; while others, with perhaps greater justice, suppose that his words apply to profane and wanton swearing, rather than to solemn and judicial oaths. Not a few of the early fathers held oaths to be unchristian; and some modern sects, such as the Quakers, &c., decline, on Scriptural grounds, to take oaths in courts of law.

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Greek oaths.

Among the Greeks, oaths seem to have been taken both between individuals and nations, on certain solemn occasions, from a very early period. When the fate of the Trojan war was to be decided by single combat, the agreement was ratified by oath. (*Iliad*, iii. 276.) A similar practice was observed in other treaties and alliances, as appears from Herod. i. 69, 74, 146, 165; Thucyd. v. 47. As is abundantly obvious from their writers, the Greeks held in great reverence the sanctity of oaths. Illustrations of this are to be found especially in Homer, Æschylus, Pindar, Euripides, and Sophocles. The ingenious prevarication and mental reservation of a Jew or a Jesuit was precisely what Homer's great hero, in his noble heathenish indignation, hated "like the gates of hell" (*Iliad*, ix. 313). The story of Glaucus the Spartan, who was annihilated with his whole family for simply entertaining the question as to whether or not he should fulfil an oath, affords a good illustration of Greek feeling upon the crime of perjury. (See Herodotus, vi. 86; Juvenal, xiii. 202.) It is but too well known, however, that, with the decay of everything great and noble among the Grecian states, the crime of perjury became an every-day occurrence; and a Greek became among the Romans only another name for a liar. Each nation or people swore by its own deity or hero: as the Thebans by Hercules, the Lacedæmonians by Castor and Pollux, and the Corinthians by Neptune. An oath was often suggested by office, character, place, or sex. Thus Iphigeneia the priestess swore by Artemis; Antilochus, in talking of horses, is told to swear by Poseidon, the equestrian deity; Achilles swears by his sceptre; Telemachus by his father's sorrows; Demosthenes by the heroes of Marathon; and Pythagoras by the number Four. If the men found it necessary to swear by Hercules and Apollo, the women felt called upon to give weight or ornament to their words by invoking Aphrodite and Demeter. Citizenship was ratified by oath in Athens, and public functionaries were sworn in to their office. It is supposed that the oaths occasionally taken by witnesses in judicial proceedings were, for the most part, voluntary among the Greeks. Oaths with the Greeks were frequently accompanied by sacrifice and libation, and the swearer placed his hands upon the victim,

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the altar, or some other sacred thing, while he was taking the oath. (Livy, xxxi. 50.)

Roman oaths.

Among the Romans, magistrates and other dignitaries had to come under an oath, in entering upon the public service, to protect and observe the laws. All Roman soldiers, on their enlistment for a campaign, had to take the military oath (*sacramentum*), binding themselves to be faithful to the commands of their superior officers. (Livy, xxii. 38.) In transactions with other nations, oaths were taken in the name of the Roman republic. Livy has recorded (i. 24) the most ancient form of this kind of oath, in a treaty struck between the Romans and the Albans. Jupiter was invoked, while the priest struck the victim with a flint-stone (*lapis silex*); and from the important part played by this instrument in oath-taking, the god himself came to be called Jupiter Lapis. During the latter years of the republic, the early reverence for international oaths became well nigh forgotten; and in perjury, both individual and national, the Roman came to rival the Jew and the Greek. The remarks already made respecting the conversational oaths of the Greeks apply pretty correctly to those of the Romans: Hercules, Pollux, Jove, and Bacchus were the favourites of the men; while women, lovers, and exquisites garnished their soft speech by appeals to Juno and Venus. Examples of this practice are endless among the classical writers. In Roman judicial proceedings, oaths were occasionally required from the plaintiff or defendant, or both. The oath of calumny (*jusjurandum calumniæ*) was taken by the plaintiff in solemn declaration that there was no malice or dishonesty in his suit. It does not seem to have been always necessary to examine prisoners on oath in civil cases; but in the criminal proceedings of the *judicia publica*, oaths appear to have been administered. (Cicero, *Pro Q. Rosc. Com.* c. 15; Noodt, *Op. Omn.* ii. 479; Digest *De Testibus.*)

English oaths.

As a general rule, all testimony in English judicial proceedings requires to be given by oath. This custom is said to have been introduced into England by the Saxons A.D. 600. Only those can be sworn as witnesses, however, who will profess their belief in the existence of Deity, in a future state of rewards and punishments, and that perjury will be punished by God. A Jew, a Mohammedan, or a Hindu may be sworn as witnesses by the oath which they severally consider binding. All other persons, such as professed atheists, &c., cannot be admitted to give evidence on oath in judicial proceedings. Young children, imbeciles, &c.; are also incompetent, from deficient intelligence. Quakers and others, who object to taking judicial oaths on Scriptural grounds, are allowed to give their evidence on affirmation, both in civil and criminal proceedings. A peer or lord of Parliament, when a dependant in Chancery, is required to give his answer to a bill upon honour only; and the members of a corporation give in their answer under the seal of their body. Oaths are also required by English law on admission to offices of public trust, as the oath of princes to rule constitutionally, the oath of supremacy, the oath of allegiance, and the oath of office. All who hold offices of any kind under the government, as members of the House of Commons, ecclesiastics, members of colleges, schoolmasters, serjeants-at-law, councillors, attorneys, &c., are required by statute to take the oaths of allegiance, &c. The oath of supremacy was first administered to British subjects (26 Hen. VIII.) in 1535; that of allegiance was framed (3 James I.) in 1605; and the oath of abjuration (13 Will. III.) in 1701. A solemn affirmation or declaration may be substituted for an oath in certain cases by the Lords of the Treasury, according to the Act 5 and 6 William IV., c. 62. (See Knight's *Political Cyclopædia*, vol. iii., p. 436.) The principal sanctions against mendacity in a witness are—(1.) The legal punishment incidental to a conviction of false swearing; (2.) The influence of public opinion; (3.) The dread of future punishment from the Deity. Bentham, in his famous attack upon the taking of oaths in his *Rationale of Evidence*, denies that the third of those considerations has the force of a sanction at all, and maintains that the first and second alone have influence. But it must be obvious to every one, that while the third sanction may not be so universal in its influence as the first and second, it may be, and in point of fact is, in the case of not a few, regarded as a consideration of infinitely greater weight than any other whatever. And, as was said already, it is the opinion of the person who takes the oath that gives it value in the eyes of the person administering or imposing it. Nothing can be more obvious, however, than the very great abuses to which the practice of oath-taking is liable. So long as the moral and religious sense of a nation is sound and pure, its public or private oaths will carry with them a becoming awe and reverence; but no sooner does the national morality begin to decline than perjury becomes an every-day occurrence, and men swear to anything that suits their interest or pleases their caprice. Such, at least, is the lesson taught us by the history of the Jew, of the Greek, and of the Roman. (See Ugolino's *Thesaurus Antiq. Sacr.*, vol. 26; Grotius, *De Jure*, &c., lib. ii., c. 13; Tyler's *Oaths, their Origin, Nature, and History*; the *Cyclopædia of Political Knowledge*; and Smith's *Dict. of Antiquities.*)

Oaxaca ‖ Oban.

OAXACA. See MEXICO.

OBADIAH, the fourth of the minor prophets according to the Hebrew, the fifth according to the Greek, and the eighth according to the chronological arrangement, is supposed to have prophesied about the year B.C. 599. (Jahn's *Introd.*) We possess but a small fragment of his prophecies, and it is impossible to determine anything with certainty respecting himself or his history. Several persons of this name occur about the same period, one of whom presided at the restoration of the temple in the reign of Josiah, B.C. 624, and is considered by many to have been the author of the prophecy. Another, who was governor of the house of Ahab, was regarded by the ancient Jews as the author of the book; an opinion followed by Jerome (Hieron. *Comm. in Abdiam*; Sixtus Senens. *Bib. Sanct.*). Others place the author in the reign of Ahaz, B.C. 728–699; while some think him to have been a contemporary of Hosea, who prophesied B.C. 722. Jahn maintains, from the warnings to the Edomites, ver. 12-14, that Obadiah prophesied before the destruction of Jerusalem by Nebuchadnezzar; while De Wette infers from ver. 20, that the composition of the book must be placed after the destruction of that city. From a comparison of Obad. ver. 1-4 with Jer. xlix. 14-16; Obad. ver. 6 with Jer. xlix. 9, 10; and Obad. ver. 8 with Jer. xlix. 7, it is evident that one of these prophets had read the other's work. That Jeremiah was the original writer has been maintained by Bertholdt, Credner, De Wette, and others. (See Eichhorn's *Introd.*, sec. 512; Rosenmüller's *Scholia*; and Jäger, *Ueb. die Zeit Obadjah.*) His prophecies are directed against the Edomites, and in this respect correspond with Amos i. 11, Jer. xlix. 22, Ezek. xxv. 12-14, and Ps. cxxxvii. 7; but he consoles the Jews with a promise of restoration from their captivity—a prophecy which was fulfilled in the time of the Maccabees, under John Hyrcanus, B.C. 125. The language of Obadiah is pure, but he is too fond of the interrogatory form of expression; his sentiments are noble, and his figures bold and striking. (In addition to the works already specified, the reader may consult Leusden's *Obadiah*; Pfeiffer, *Comm. in Obad.*; Schröer, *Der Prophet Obad.*, &c.; Venema, *Lectt. in Obad.*, with the additions of Verschuir and Lohze; Kohler, *Anmerkk.*; Schnurrer's *Dissert. Philol.*; Hendewerth, *Obadjæ Prophetæ Oraculum in Idumæos.*)

OBAN, a parliamentary burgh and seaport of Scotland, Argyllshire, 20 miles N.W. of Inverary, and 6 ¼

Obe || Oberlin.

N.W. of Glasgow. It is built in the form of a crescent, round the shore of a bay of the same name, and has an extensive coasting trade with the Clyde, as it is the chief seaport and market-town for a large extent of country. It contains places of worship belonging to the Established, the Free, the United Presbyterian, the Scottish Episcopal, and the Independent churches; several schools, a library, reading-room, savings-bank, and custom-house. The harbour is deep and safe, being sheltered by the island of Kerrera; and the inhabitants are extensively engaged in fishing. Steamers ply regularly between this town and Glasgow; and during the summer it is a great resort for tourists, who make this their starting-place for the various parts of the Western Highlands. The Bay of Oban is surrounded by steep cliffs, on which stand the ruins of Dunolly Castle; while about three miles to the north of the town are the remains of that of Dunstaffnage. Oban unites with Ayr and other burghs in returning a member to Parliament. Pop. (1851) 1742.

OBE, OBI, or OBY, a river of Siberia, rises in the Altai Mountains, where it is formed by the union of two main streams, the Katunga and the Biya. It flows in an irregular course, but generally towards the N.W., till it joins the Irtish from the south. It then turns northward, and flows in that direction, frequently dividing itself into two streams, which flow separately for long distances, and then unite again. It falls into the Gulf of Obe by three branches, the largest and deepest of which is that which lies to the east. Its whole length is estimated at 2000 miles. The principal affluents of the Obe are the Irtish, which is longer than the branch which retains the name of Obe, the Tom, the Choolyn, and the Ket; while the Irtish receives from the west the Tobol and the Iskim. Both the Irtish and the Obe abound in fish, which might be made a valuable article of export. The country drained by the Obe and its tributaries is calculated to have an area of 1,370,000 square miles. The Gulf of Obe, which derives its name from the above river, is an inlet of the Arctic Ocean, between 70 and 80 miles in breadth, and upwards of 400 in length. It lies between N. Lat. 67. 30. and 72. 30.; E. Long. 72. and 77.

OBELISK, a truncated, quadrangular, and slender pyramid, raised as an ornament, and frequently charged with inscriptions or hieroglyphics. Obelisks appear to have been of very great antiquity, and first raised to transmit to posterity certain precepts, which were cut in hieroglyphical characters; but they were afterwards used to immortalize the great actions of heroes and the memory of persons who were beloved. The first obelisk mentioned in history was that of Remeses, King of Egypt, which was forty cubits high. Phius, another king of Egypt, raised one of fifty-five cubits; and Ptolemy Philadelphus, another of eighty-eight cubits, in memory of Arsinoë. Augustus erected one at Rome, transported from Egypt, in the Campus Martius, which served to mark the hours on a horizontal dial drawn upon the pavement. They were called by the Egyptian priests the "fingers of the sun," because they were made in Egypt to serve also as styles or gnomons for marking the hours on the ground. The Arabs still call them "Pharaoh's needles." (See the elaborate work of Zoëga, *De Origine et Usa Obeliscorum*, illustrated with very beautiful and accurate plates; Sir G. Wilkinson's *Ancient Egyptians;* and articles ARCHITECTURE and EGYPT.)

OBERLIN, JEAN FREDERIC, a celebrated philanthropic pastor, was the son of a teacher, and was born at Strasburg on the 1st August 1740. Under the religious instructions of his mother, and of a devout Lutheran preacher named Dr Lorentz, he imbibed that spirit of pious zeal which determined his future career. Before the age of twenty he had formally dedicated himself to God; and at the close of his university course he became a minister of the French Protestant Church. The great work of his life, however, did not commence until, in 1767, he was appointed to the curacy of Waldbach in the valley of Ban de la Roche in Alsace. He then found himself among a few ignorant and half-savage parishioners, who were shut up from the civilized world within the cold bosom of their native mountains, were scattered over a stony uncultivated valley, lived upon wild apples and pears, and shivered in filthy cabins of turf. His first act was an attempt to induce the natives to open up their country by making regular highways. But he soon found that all his ardent expositions of the advantages of trade could not excite their sluggish desires. He therefore seized a mattock, and began to make a road with his own hands. This action struck the peasants like an electric shock. They could not stand idly by while their delicately-nurtured pastor was sweating in their behalf: young and old came flocking to give their assistance; highways began to traverse the valley; a bridge was thrown over a turbulent stream that interrupted all intercourse with Strasburg; and in a short time commerce was beginning to circulate through the country. The same mode of teaching by example was used to introduce agriculture. The pastor brought a patch of ground that was by the wayside under cultivation; the fine crop, as it grew ripe, excited the envy of all that passed by; they came in crowds to learn the secret of his agriculture; he gave them both instruction and assistance; and the result was that the desert of Waldbach soon began to "blossom as the rose." To improve the domestic economy of his parishioners was the next endeavour of Oberlin; and he did it like one who, after the example of the Divine Master, deems it a sacred task to relieve even the meanest want of humanity. He assisted the men in building comfortable cottages; despatched the idle boys to the neighbouring districts to learn farming or the mechanical trades; set the unemployed girls to knitting, straw-plaiting, and cotton-spinning; and instructed the housewives in using certain common plants for food and medicine. The love and gratitude which the natives felt for all these benefits, opened their hearts to receive the higher lessons of their pastor. His homely sermons on Sabbath, his prayer-meetings during the week, his habit of blending religion with all the duties of common life, and his humble and active piety—all contributed to soften down their rough and stubborn dispositions. He induced them to start an itinerant library, to establish the first specimens of infant schools that had ever existed, and to build an ordinary school at each of the five villages in the parish. It was not even thought impertinent when he kept a register of their moral characters, and inquired into the most paltry of their family affairs. In fact, he had now come to be considered the father of his flock; and no circumstance in his large household was thought too trifling to demand his loving attention. The latter half of Oberlin's life was spent in superintending the social organization which he had established in his parish, in entertaining the many pious individuals who came from different parts of Europe to visit him, in circulating copies of the Bible throughout France, and in advancing the cause of missions in heathen countries. He died on the 1st June 1826, and was interred with great honour, and in the presence of a great concourse of people, at the village of Foudai. The name of Oberlin was associated for some time afterwards with the active piety of Louisa Schepler, a humble woman, who had lived in his house for fifty years in the capacity of servant and housekeeper. This simple-hearted peasant continued till her death in 1837 to teach in the schools of the valley, to consecrate all her little earnings to Christian charity, and to wait without remuneration on the children of her beloved master. (*Brief Memorials of Oberlin*, by the Rev. Thomas Sims, M.A., London, 1830; and *Memoirs of Oberlin, with a Short Notice of Louisa Schepler*, London, 1838 and 1852.)

Oberlin.

Oberlin ‖ Object.

OBERLIN, *Jeremie Jacques*, a learned antiquary and philologist, the elder brother of the preceding, was born at Strasburg in 1735, and entered the university of his native place. His career was distinguished from the very first by an unwearied devotion to antiquarian research. At the end of his philosophical course, he produced a thesis, entitled *De Veterum Ritu Condiendi Mortuos*. Then, commencing a theological curriculum, he turned his attention exclusively to the archæology of the sacred writings. Nor were his favourite studies discontinued when he was appointed assistant and successor to his father in the laborious duties of an elementary teacher in the gymnasium. He requested and obtained permission from the university of Strasburg to deliver a course of lectures on the Latin tongue; he prelected and published manuals on archæology and ancient geography; and he made frequent excursions into various provinces of France to investigate the antiquarian remains and the provincial dialects of the country. At length, in 1782, his appointment to the chair of logic and metaphysics at Strasburg brought his philosophical activity into full play. He published *Dissertations sur les Minnesingers* in 1782-89; an edition of Horace in 1788; and *Observations concernant le Patois et les Meurs des Gens de la Campagne* in 1791. The troubles of the French revolution interrupted his studies; and in 1793 he was imprisoned for some time at Metz; but on the restoration of tranquillity he returned with fresh zest to his books. His edition of Tacitus appeared in 1801; and his edition of Cæsar in 1805. He was engaged in editing Justin, when he was cut off by a stroke of apoplexy in 1806.

OBERNAI, or OBERHEHNHEIM, a town of France, in the department of Lower Rhine, 14 miles N. of Schelestadt. It is ill built; and has a large town-hall, college, and hospital; while in the vicinity are the ruins of a palace and a convent. Calico, leather, hats, soap, bricks, earthenware, nails, &c., are made here. The town was once fortified; and has sustained several sieges. Pop. 5356.

OBIDOS, a fortified town of Portugal, province of Estremadura, stands on the Arnoia, where it enters the lagoon of Obidos, 47 miles N. by W. of Lisbon. It has some ancient remains; and is remarkable for a victory gained here by the British under Wellington over the French, 15th August 1808. Pop. 3000.

OBJECT AND OBJECTIVE, SUBJECT AND SUBJECTIVE, are two pairs of correlative terms, much used in philosophical speculation, and not always free from ambiguity. The foundation of this capital distinction in philosophical terminology is to be found in the ultimate analysis of knowledge itself, of which philosophy lays claim to be the science. For if knowledge is the result of a relation between that which knows (the subject) and that which is known (the object), it follows that the terms Subject and Subjective, Object and Objective, stand forth as opposing contraries, to mark off compendiously the grand, the fundamental distinction which lies at the root of all knowledge. The general discrimination indicated by those terms is at once articulate and precise; but in their special application they are liable to ambiguity and equivocation. The Subject, as now commonly employed by philosophers, denotes that which knows; and is limited exclusively to the Ego, or conscious mind, called by the Germans *Das Ich*, and by the French *Le Moi*. Subjective, is employed in like manner to express what pertains to the mind, the Ego or thinking principle. The terms Object and Objective, again, are employed generally in contrast and correlation to these, to denote that which is known, the Non-ego, with its modes and properties, called by the Germans *Das Nicht-Ich*, and by the French *Le Non-Moi*. But it is obvious that the terms Subjective and Objective, while generally distinguishing what belongs to mind from what belongs to matter, are not quite thorough and unambiguous in their discrimination. For the object known is not of necessity a mode of what is called matter, or of the Non-ego. If I am conscious of joy or sorrow, for example, or call before my imagination the representation of a distant object, it is obvious that what the mind contemplates is, in this case, wholly in and of itself—is as emphatically a mode of the Ego as extension is of the Non-ego. But if the phenomena of the thinking subject can thus become objectified, so to speak, and converted into the object known, there at once emerges a palpable equivocation in the use of the terms Object and Subject. This ambiguity may be effectually avoided, however, by coupling with those terms a qualifying attribute when it is necessary to do so. While, therefore, Subject and Subjective should be employed in their simplicity to denote what belongs to, or is dependent on, the knowing mind, whether of man in general or or some man in particular; and Object and Objective to express what does not so belong or depend; some nomenclature is requisite to mark off precisely an object of knowledge as a mode of mind on the one hand, or as something different from mind on the other. "Without, therefore," says Sir William Hamilton, "disturbing the preceding nomenclature, which is not only ratified but convenient, I would propose that, when we wish to be precise, or when any ambiguity is to be dreaded, we should employ, on the one hand, either the terms *subject-object*, or *subjective object* (and this we could again distinguish as absolute or as relative); on the other, either *object-object* or *objective object*." With respect to the alternative indicated above parenthetically of the absolute or relative element in subjective objects, he remarks in another place, "But the *subject-object* may be either a mode of mind of which we are conscious as absolute, and for itself alone,—as, for example, a pain or pleasure; or a mode of mind of which we are conscious as relative to, and representative of, something else,—as, for instance, the imagination of something past or present. Of these we might distinguish, when necessary, the one as the *absolute* or the *real subject-object*; the other as the *relative* or the *ideal*, or the *representative subject-object*. Finally, it may be required to mark whether the *object-object* and the *subject-object* be immediately known as present, or only as represented. In this case we must resort, on the former alternative to the epithet *presentative* or *intuitive*; on the latter to those of *represented, mediate, remote, primary, principal*," &c. See Hamilton's edition of Reid, note B; in which there will be found a historical and critical exposition of the use of these terms in the Greek and scholastic philosophy. (See also *Dictionnaire des Sciences Philosophiques*.)

Oblate ‖ Obojan.

It may not be improper to observe, that the words Subject and Object, besides possessing the technical signification just described, are also used in a popular sense entirely different. Thus, in the expression "subject of discourse," the word "subject" is employed for the *materia circa quam*, where object would be exclusively applied in philosophy. *Object* is also vulgarly used, both in France and England, for *end, motive, final cause*, &c.

OBLATE, flattened or shortened, as an oblate spheroid, having its axis shorter than its middle diameter, and being formed by the rotation of an ellipse about its shorter axis. The earth, the polar diameter of which is shorter than the equatorial, is an oblate spheriod.

OBLIQUE signifies generally something aslant, or deviating from the perpendicular. Thus an oblique angle is either acute or obtuse; that is, any angle except a right one.

OBLONG, in general, denotes a figure the length of which exceeds the breadth; as, for example, a parallelogram.

OBOLUS, an ancient Greek coin. (See NUMISMATICS.)

OBOJAN, a town of Russia, in the government of

Observatories ‖ Occam.

Kursk, stands at the confluence of the Obojanka and Psiol, 36 miles S. of Kursk, and about 370 W.S.W. of Moscow. It is well built; has several churches, schools, and hospitals; and drives a flourishing trade in cattle, wax, &c. Pop. (1849) 4968.

OBSERVATORIES. (See ASTRONOMY, *Supplement* to part i.)

OBY, a small island in the Malay Archipelago, S. of Gilolo; S. Lat. 1. 30., E. Long. 127. 50. It is about 50 miles in length, and varies from 10 to 20 in breadth. It has lofty mountains and dense woods, and yields spices and sago. The Dutch have a settlement at the west end; and near this is another island called Little Oby.

OCAÑA, a town of Spain, in the province of Toledo, 35 miles S. of Madrid, and 26 E. of Toledo. It is an ancient town, built on the sides and top of a hill, and is surrounded by ruinous walls. The streets are narrow and ill built, but there are several handsome squares, churches, convents, schools, an hospital, and a prison. The town is supplied with water by a stone aqueduct of nineteen arches, supposed to have been built by the Romans. Manufactures of soap, bricks, earthenware, cloth, &c., are carried on. In the neighbourhood the Spaniards sustained in 1809 a signal defeat from the French. Pop. 4789.

OCAÑA, a town of New Granada, capital of a province of the same name in the department of Guanenta, on the Oro, 60 miles N.W. of Pamplona. It stands among the Andes; and there are copper mines in the vicinity. Some trade is carried on by the River Oro and the Canaverales, into which it falls. Pop. of town, 5500; of province, 23,450.

OCCAM, or OCKHAM, WILLIAM OF, an English scholastic philosopher, and the great champion of Nominalism in the fourteenth century, was born at Ockham in Surrey in the latter half of the thirteenth century. He repaired to Paris at an early age, having been expelled from Oxford for exciting tumults among the students. On reaching that city he joined the ranks of the Franciscans, and sat at the feet of their great chief, Duns Scotus, "the most subtle Doctor." Nothing is known respecting Occam until he appeared as a public teacher in Paris. In this capacity he produced an extraordinary sensation. By the boldness of his speculations and the vehemence of his dialectics, mere tradition, no matter how venerable, whether political, religious, or philosophical, found no quarter with William of Occam. "The invincible Doctor," as he soon proved himself, threw the weight of his influence, as the advocate of Nominalism and free opinion, and the sworn foe of Realism and intellectual submission, on the side of Philip the Fair of France in his contest with Pope Boniface VIII. William published a celebrated manifesto in favour of the cause, entitled *Disputatio super potestate ecclesiastica prælatis atque principibus terrarum commissa*, which the successor of St Peter did not at all relish. The author and his followers were branded as innovators in the church as well as in the schools; and Nominalism became with the ecclesiastical party another name for heresy. On the death of Boniface, Pope John XXII. summoned Occam and his disciples before him at Avignon, and the "invincible Doctor" only escaped the vengeance of his Holiness by a precipitate flight to Bavaria, on the 26th of May 1328. Here he gained the protection of Louis, and remained till his death, which took place at Munich some twenty years afterwards. (For the doctrines of Occam, see NOMINALISM AND REALISM.)

The following writings compose Occam's philosophical works:—*Super libros Sententiarum subtilissimæ quæstiones*, fol., Lyon, 1495, in which will be found the substance of the author's metaphysical doctrines; *Quodlibeta septem*, fol., Paris, 1487, and Strasburg, 1491; *Summa logices*, 4to, Venezia, 1591, and frequently reprinted; *Major summa logices*, 4to, Venezia, 1522; *Quæstiones in libros Physicorum*, fol., Strasburg, 1491, 1506; *Expositio aurea super totam artem veterem, videlicet in Porphyrii prædicabilia et Aristotelis prædicamenta*, fol., Bologna, 1496.

Occulation ‖ Ochino.

OCCULTATION is that phenomenon in which a star or planet becomes concealed from our view by the intervention of the moon. (See ASTRONOMY.)

OCCUPANCY, in *Law*, is the taking possession of that which before belonged to no one in particular. This, according to Blackstone (*Commentaries*, b. ii., c. 16), is the true ground and foundation of all property, or of holding those things in severalty which by the law of nature, unqualified by that of society, were common to all mankind.

OCEAN. See PHYSICAL GEOGRAPHY.

OCEANIA. See AUSTRALASIA.

OCEANUS, an ancient Greek god, was the son of Uranus and Gæa, and the eldest of the Titans. Homer and Hesiod represent him as a divinity of might and importance, and they each mention several elements in his greatness. He was the father, by Tethys, of the rivers, and of the 3000 Oceanides, the goddesses of the rivers; he dwelt in a palace in the far west; and "the ocean stream" over which he ruled encircled the whole earth, and touched the vault of heaven on every side.

OCELLUS LUCANUS, a Pythagorean philosopher, born in Lucania in Italy, as his name implies, and supposed to have flourished during the fifth century B.C. He is said to have been a contemporary as well as a disciple of Pythagoras. The only definite information we possess respecting Ocellus—and even that is not of the most authentic character—is to be found in two letters cited by Diogenes Laërtius (lib. viii., c. 80, 81), in which Archytas sends Plato a reading of four works of the Lucanian philosopher. Plato, in acknowledging the receipt of the precious MSS., expresses his admiration of their contents. These books contained treatises on Law, on Kingly Rule, on Piety, and on the Nature of the Universe. Of these writings, the only one which has come down to us is the last, entitled Περὶ τῆς τοῦ παντὸς φύσιος; written originally in Doric Greek; but the authorship of it is by no means clear. The best editions are those of Rudolphi, Leipsic, 8vo, 1801; and of Mullach, Berlin, 1846. The Marquis D'Argens published an 8vo edition at Berlin, 1762, with a French translation and a commentary. There is a good edition by Batteux, 3 vols. 12mo, Paris, 1768; and an English version of Ocellus was published in 8vo, 1831, by Thos. Taylor.

OCHINO, or OCHINUS, BERNARDINO, a famous Italian ecclesiastic, was born at Sienna in 1487, and assumed the monkish garb at an early age. After living for some time among the Franciscans, he passed over to the Capuchins, and was elevated in 1537 to the rank of general of that order. From that time Ochino was distinguished for his bold and earnest self-devotion to whatever he considered his duty. His simple and touching eloquence was zealously exerted in behalf of the church and his own order; none of the favours which admiring princes attempted to heap upon him could excite his cupidity; and he was content to be known throughout Italy as an itinerant preacher and a squalid, emaciated ascetic. In 1541, when the truth of the Protestant doctrines dawned upon him, he did not hesitate to cast away the great popularity he had gained in the Church of Rome, and to become a fugitive and a wanderer for the sake of his honest conviction. After taking refuge in Geneva and Augsburg, he found an asylum in England, in 1547. The accession of Mary in 1553 drove him back to the Continent; and not until 1555 did he obtain a permanent footing as minister of an Italian church at Zurich. Before eight years had passed, his fearless avowal of his opinions brought him once more into trouble. Happening, in a volume of dialogues which he published, to maintain that polygamy was lawful under certain circumstances, he was driven forth from Switzerland in mid-winter to find another home. He retreated into Poland; but no heretics could remain there. Worn out with age and travel, he

Ochil Hills || O'Connell, Daniel.

turned to go into Moravia: the plague overtook him at Slawkow, and he died in 1564.

Ochino was the author of a collection of sermons, which was published in Italian, at Basle, in 5 vols. 8vo, 1562. Several of them have been translated at different times into English. He also wrote commentaries on the epistles to the Romans and Galatians, and some pamphlets against Popery.

OCHIL HILLS, a mountain range of Scotland, in the county of Perth, about 24 miles in length, and having an average breadth of 12 miles. They extend from within 2 miles of the Forth, near Stirling, in a N.E. direction, to the Firth of Tay. The highest point is Bencleugh, at the S.W. extremity, 2300 feet above the level of the sea. The geological formation is basalt and greenstone, probably covering Silurian formations; and iron and copper ores have been found. The greater part of the hills afford good pasturage for sheep.

OCKLEY, Simon, an eminent orientalist, and professor of Arabic in Cambridge, was born at Exeter in 1678. He was educated at Cambridge, and distinguished himself by uncommon skill in the oriental languages. Having taken a degree in divinity, he was, in 1705, presented by Jesus College with the vicarage of Swavesey, and in 1711 he was chosen Arabic professor of the university. He had a large family, and his latter days were rendered unhappy by pecuniary embarrassments. He died in the year 1720. The principal works of Ockley are, *Introductio ad Linguas Orientales*, 1706; *The History of the Jews throughout the World*, from the Italian of Leo of Modena, 1707; *The Improvement of Human Reason*, from the Arabic, 1708; *The History of the Saracens*, in 2 vols. 8vo, 1708–18. This last work was compiled from Arabic manuscripts in the Bodleian Library at Oxford, and is justly valued for its accuracy and erudition.

OCLISEER, a town of British India, in the district of Broach, presidency of Bombay, 35 miles N. of Surat, and 50 miles S. of Baroda, on the route between these two towns. Pop. 7000.

O'CONNELL, Daniel, a celebrated political agitator, was born at Carhen, in the neighbourhood of Cahirciveen, in the county of Kerry, on the 6th of August 1775. He was descended from an old Roman Catholic family in his native county, who could boast more of the antiquity of their descent than of the affluence of their circumstances. His father, Morgan O'Connell, if not a rich man, possessed at least a tolerable competence, the fruits of his own industry and prudence; and enjoyed the advantage, during those stirring times, of comparative seclusion amid the romantic wilds of Kerry. Daniel received his first lesson from a poor old hedge-schoolmaster, who being engaged on a begging expedition, took a fancy for the child, and is said to have taught him his alphabet at a single sitting. At the age of thirteen O'Connell was sent to a school at Redington, Long Island, near Cove, conducted by a Catholic priest named Harrington. After spending a year at this institution without, according to Fagan, giving much indication of superior talent, young O'Connell and his brother were removed by their uncle Maurice, who had adopted the lads, with the design of being sent to some suitable place of learning on the Continent. They accordingly entered the Jesuit's college of St Omer's in France in 1791, and after remaining a year there, they removed to the English college of Douai. At the former institution Daniel seems to have carried all before him, and the principal, Dr Stapylton, wrote of him when leaving, "I never was so much mistaken in my life as I shall be, unless he be destined to make a remarkable figure in society." The outbreak of the French revolution brought their studies to a close, and the two young Irishmen turned their faces towards England the same day the unfortunate Louis lost his head at Paris. The atrocities of the Reign of Terror produced a strong impression on the mind of O'Connell; and he had no sooner got on board the English packet-boat at Calais than he plucked the tricolor cockade from his cap, trampled it under his feet, and flung it into the sea. He returned to Ireland, he said, almost a "Tory at heart." During his absence the rigour of the penal laws against Roman Catholics had become somewhat relaxed; and the profession of law was now thrown open to the Catholic as well as the Protestant. O'Connell resolved to prepare himself for the Irish bar, and became a student at one of the Inns of Court in London in 1794. He was called to the bar in 1798, and commenced a most brilliant career as a legal pleader. Politics do not seem to have occupied much of his public attention at this period, and he even held aloof from the wild and unscrupulous revolutionists of his time. The policy which subsequently guided his public life had already taken hold of his mind. "He would accept of no social amelioration at the cost of a single drop of blood."

O'Connell, Daniel.

O'Connell made his first public appearance at a political meeting held by the Catholics of Dublin in the Royal Exchange Hall, on the 13th of January 1800, to petition against the proposed union of the English and Irish legislatures. In this short speech are to be found in germ the fundamental ideas of his public life. There is a certain stiffness and formality about it, doubtless incidental to youth and inexperience; but it is pervaded by a sturdy energy and clear-headed determination which gives solidity to his patriotic indignation, and commands instant respect. From this period O'Connell gradually assumes a leading place among the political agitators of the day. In 1802 he was privately married to his cousin Mary, daughter of Dr O'Connell of Tralee. The disastrous insurrection of 1803, known as "Emmett's rebellion," found O'Connell enrolled among the "lawyer's infantry" in the general arming which then took place. The calamitous results of that unhappy movement, and the temporary cruelties which it entailed, served more and more to inflame the passions of the disaffected, and gave an increasing prominence to the "Catholic question." The "Catholic Board," having incurred the displeasure of the government, was dissolved by proclamation in 1804; but the zeal and activity of its adherents succeeded in reviving it soon after under the title of the "Catholic Committee." Regular reports of the debates of this body are to be found in the Dublin newspapers from 1808. O'Connell, who was now in good practice, and who seems to have been regarded as the most promising barrister of the day, directed his surprising energies more systematically and continuously to the cause of the Roman Catholics; and became the acknowledged leader of political reform in Ireland. It is to this period of his life that O'Connell alludes in his pamphlet written in reply to the attack of Lord Shrewsbury in 1842, when he rebuts the taunt of receiving "the rent," as it was called, in the following words:—"For more than twenty years before emancipation, the burden of the cause was thrown upon me. I had to arrange the meetings, to prepare the resolutions, to furnish replies to the correspondence, to examine the case of each person complaining of practical grievances, to rouse the torpid, to animate the lukewarm, to control the violent and the inflammatory, to avoid the shoals and breakers of the law, to guard against multiplied treachery, and at all times to oppose, at every peril, the powerful and multitudinous enemies of the cause. . . . At that period, and for more than twenty years, there was no day that I did not devote from one to two hours, often much more, to the working out of the Catholic cause, and that without receiving or allowing the offer of any remuneration, even for the personal expenditure incurred in the agitation of the cause itself." The most painful occurrence, of a personal kind, of O'Connell's entire career took place

O'Connell, Daniel.

in 1815. Having applied the term "beggarly" in one of his speeches to the Dublin corporation, one of the members of that body, Mr D'Esterre, came forth in defence of its injured dignity, and demanded satisfaction from the agitator. A duel followed, which ultimately proved fatal to D'Esterre. O'Connell never ceased to express the most painful regret at the issue of this melancholy affair. Beyond the general indication just given of the services rendered by him to the cherished cause, nothing of very special importance in O'Connell's career demands attention until the summer of 1828, when the decisive struggle for Roman Catholic emancipation had reached its crisis. A vacancy having occurred in the representation of the county of Clare in the month of June of that year, O'Connell was proposed as a candidate, despite his adherence to the Roman Catholic faith, and was returned to Parliament by a great majority. On reaching Westminster, he refused to take the oaths, which had been framed with the express design of excluding Roman Catholics. The attitude which he assumed had the effect of bringing the civil disabilities of his party prominently before the nation. A year passed away full of keen and noisy debate, both in and out of Parliament, without any decisive result; yet the influence of intelligent public opinion, even among Protestants, was waxing so strong in favour of Catholic emancipation, that the following year witnessed the repeal of the last of those civil disabilities to which Roman Catholics had been so long and so unjustly subjected. O'Connell took his seat as a member of Parliament in May 1829. Here he seems to have been both feared and disliked, and was received by the House with the most icy coldness. The day came, however, when his matchless oratorical powers were recognised, and he ultimately became perhaps the most attractive debater in the House of Commons. (See an excellent sketch of the public speakers of that period in the *New Monthly Magazine* for 1832.) The career of O'Connell is of necessity so much interwoven with the public history of the time, from his entry upon his parliamentary duties, that the reader will find his subsequent history placed in the most intelligible light by referring to the articles BRITAIN, and IRELAND. At the general election in 1830 he was returned for his native Kerry. He represented Dublin from 1832 to 1835, when he was unseated. The following year he sat for Kilkenny; in 1837 he was once more returned for the capital; and in 1841 he was chosen representative of the county of Cork. The Conservatives came into power in 1841, and the great Irish agitation in behalf of the repeal of the Union began to assume a formidable character. "Monster meetings" were held all over the country. The "rent," or annual subscription for the support of the "Liberator" and the cause of repeal, poured in in the most cheering manner; and O'Connell strove to unite all Irishmen in the struggle. He announced in the Repeal Association—"1843 is, and shall be, the great repeal year." Spots rendered sacred by tradition and song were chosen as rallying-points for the indignant display of popular independence; and the royal hill of Tara, the curragh of Kildare, and the rath of Mullaghmast, shook with the noisy patriotism of thousands upon thousands of wild ignorant Irishmen. The chief laid aside for a time the dignified eloquence of the senator, and adopted a style better adapted to captivate the hearts of his admiring fellow-countrymen. Like Nestor of old in the camp of the Greeks, "the words distilled from his lips like honey;" but it is to be feared there was more "blarney" than wisdom in them. No man knew better than O'Connell what to say, and when to say it; and if he treated the House of Commons to splendid displays of fiery logic, impassioned invective, and brilliant retort, he knew well where a slight touch of swagger gave a man a kingly air, where a rare joke went farther than a good argument, where big words passed for wisdom, and loud ones for courage. "The great Irish people" who believed in repeal were down on their knees before the "Liberator:" his heart was cheered within him; and out of the abundance of his generosity he made the most liberal promises. "I hope," he said, "to be able to give you, as a New Year's gift, a Parliament in College Green." Other cheer awaited that festive season, however. Another "monster meeting" was projected at Clontarf, three miles from Dublin, at which the choice of those swaggering patriots were to appear on horseback, and parade before the idle and applauding multitude as the glorious "Repeal Cavalry." But the Irish government failed to sympathize with this grand conception; and the iron hand of power was lifted menacingly in the face of repeal. The prohibitory proclamation of government was followed up by a peaceful recommendation from the "Liberator," who always strove to steer clear of a physical collision. This proclamation was issued on the 7th of October 1843, and ere seven days had passed, the Chief and a number of the leading repealers were arrested on a charge of conspiracy and sedition. O'Connell had, throughout his entire career as a political agitator, manifested the most consummate skill and self-command in constantly treading on the very verge of constitutionalism, and yet always keeping within the bounds of strict legal activity. Attempts had previously been made to convict him of sedition, but to no purpose. But the flush of success of "the great repeal year" apparently threw him off his guard, and the "Liberator" was now within the clutches of the law. After a trial of twenty-four days, the Irish judges sentenced O'Connell to imprisonment for twelve months, with a fine of L.2000, and bound him over to keep the peace for seven years. The judgment was carried before the House of Lords, and the decision of the Irish judges was reversed. This trial had the effect of dissolving the charm exercised by the "Liberator" in Ireland: it well nigh beggared the Repeal Association, and indeed gave the death-blow to the entire movement. O'Connell's doctrine of the absolute renunciation of physical force in seeking political amelioration met with no favour at the hands of the "Young Ireland" party; and in 1846 they seceded from a leader who had been the champion of the cause for forty years. The Irish famine was only needed to break the spirit of the indomitable O'Connell. With failing health and a heavy heart, he set out on a devotional pilgrimage to Rome in 1847, but he had only reached Genoa, when he was suddenly called to lay down his load on the 15th of May of the same year. At his own request, his heart was embalmed and borne to Rome, and his body was carried back to the land which he had loved so well. He left three daughters and four sons to lament his loss. His eldest son Maurice, for many years the representative of Tralee, died in 1853. The *Memoir on Ireland* written by O'Connell never got beyond the first volume.

(See the *Life and Speeches of Daniel O'Connell, M.P.*, by his son, John O'Connell, M.P., 2 vols., 1846; *The Life and Times of Daniel O'Connell*, by William Fagan, M.P., 2 vols., 1847; *Personal Recollections of Daniel O'Connell*, by Daunt, 2 vols., 1848; *Last Days of Daniel O'Connell*, by Maccabe, 1847.) (J. D—S.)

Octagon ‖ Octavia.

OCTAGON, an eight-sided polygon. (See GEOMETRY.)

OCTAHEDRON, one of the five regular solids contained by eight equal and equilateral triangles. (See GEOMETRY, part ii.)

OCTAVIA, the youngest daughter of Caius Octavius, and the sister of Augustus. She was the widow of Caius Marcellus in 40 B.C., when her brother and Mark Antony concluded their recent variances by a formal treaty of agreement. Her marriage with the latter was then proposed as a means of still further strengthening the union between the two triumvirs. To save her country from

civil broils, and to please her brother, the noble-minded matron sacrificed herself, and wedded the notorious libertine. It soon appeared that along with her hand she had given her life's devotion. As long as Antony remained at home, her wisdom, her virtues, and the charms of her mature beauty, were zealously employed to keep him on good terms with Octavianus. When he deserted her in 36 B.C., for the syren charms of Cleopatra, her conjugal fidelity remained unabated. In the following year she set out for Egypt to endeavour to regain his vagrant affections; on receiving at Athens an order from him to return home, she immediately obeyed; and it was not until, in 32 B.C., he sent her a bill of divorce, that she could be prevailed upon to leave his house in Rome. Even after his death in 30 B.C., she did not think that her obligations to serve him were at an end. She continued to bring up his younger son by his first wife Fulvia; and when his children by Cleopatra were brought to Rome to grace the triumph of Octavianus, she adopted them into her own family. Octavia had now for several years been constantly attended by misfortune; but the great and the closing sorrow of her life was yet to come. In 23 B.C. Marcellus, her son by her first husband, the idol of the Roman people, and the heir-presumptive to the empire, died at the age of twenty. She fell into a state of melancholy, which continued till her death in 11 B.C.

The great worth of Octavia was celebrated by a public interment, and by a funeral oration delivered by her imperial brother. Her memory was preserved by a magnificent edifice built by Augustus, and called "Porticus Octaviæ."

OCTAVIA, the grand-daughter of the preceding, was the daughter of the Emperor Claudius and Messalina, and was born about 42 A.D. Her short life was a series of the most cruel wrongs. At the age of six she was betrothed to Lucius Silanus, a young man of noble birth. About her eleventh year this betrothal had been nullified by the designs of her step-mother, the infamous Agrippina; and she was married to Nero, the son of the latter, and the heir to the empire. Nine years afterwards Nero, by that time emperor, divorced her on the charge of sterility, in order to make room for Poppæa. The innocent young princess next became the victim of the systematic vengeance of her triumphant rival. An attempt was first made to force her servants to accuse her of incontinency; but not even the torture could wring from them a word against the reputation of their mistress. She was then exiled into Campania; but the people soon brought her back to Rome in triumph. At length the slave Anicetus was hired to procure her condemnation, by swearing that he had been her paramour. The helpless girl, in her twentieth year, was immediately taken away to the island of Pandataria to be put to death. Her veins were opened by the soldiers; extreme fear, however, prevented the blood from flowing; and it was found necessary to stifle her in the steam of a hot bath. The woes of Octavia form the subject of a tragedy found among the works of Seneca, and they have also been dramatized by Alfieri.

OCTOBER, in chronology, the eighth month, as the name implies, of the old Roman year; but the tenth in the calendar of Numa, Julius Cæsar, &c. The senate gave this month the name of *Faustinus*, in compliment to Faustina, the wife of the Emperor Antoninus; Commodus wished it to be called *Invictus;* and Domitian named it *Domitianus*; but in spite of all these attempts it still retains its original name. This month was sacred to Mars; and a horse, called the *October Equus*, was annually sacrificed to that deity. A race was run with chariots previously to the sacrifices, when the fleetest horse was made the victim.

ODE, a short lyrical poem containing a vivid expression of the feelings of the poet in moments of high excitement. Among the Greeks and Romans the ode (ᾠδή, *a song*) was intended to be sung, and was usually accompanied by some musical instrument, especially the lyre. Hence the expression "lyric poetry," of which the earliest forms seem to have been the ode. The most celebrated classical odes are those of Pindar, Anacreon, and Horace, which are still recognised by the moderns as models in that species of poetical composition. In the modern use of the word, however, the ode differs, on the one hand, from the song, by greater length and variety, and by not being necessarily adapted to music; and, on the other, from the ballad, by generally excluding narrative, and limiting its range exclusively to the expression of feeling or passion on a given subject. In English literature the odes of Dryden, Gray, and Collins are much esteemed. (See POETRY.)

ODEIPORE, a raj of British India, under the jurisdiction of the political agent for the S.W. frontier of Bengal; N. Lat. (of centre) 22. 40., E. Long. 83. 23.; area 2306 square miles. This territory was forfeited to the British government on account of the systematic crimes of the rajah, and the want of direct heirs. The annual revenue is estimated at L.1500. Pop. 133,000. The chief town is Odeipore, 183 miles S. of Benares, and 320 W. of Calcutta.

ODENATHUS, a famous prince of Palmyra, and husband of the celebrated Zenobia. (See PALMYRA.)

ODENSE, a seaport-town of Denmark, capital of the island of Funen, on the N. bank of the Odense-Aue, a small stream flowing into the fiord of the same name, 88 miles W. by S. of Copenhagen. It is one of the oldest places in Denmark, and is said to have been founded by Odin, whose grave is shown about a quarter of a mile to the N. of the town. The cathedral, in the Gothic style, founded by Canute IV. in 1080, and completed in 1301, is one of the finest ecclesiastical buildings in Denmark, and contains the tombs of several Danish kings. There are here also an old episcopal palace, a royal palace, a town-hall, several schools, a theatre, two public libraries, an hospital, &c. The manufactories of the place consist of breweries, distilleries, iron-foundries, and woollen mills; and some trade is carried on, which is facilitated by several harbours near the town. Pop. (1851) 11,122.

ODENSWALD, a range of mountains of Western Germany, in Hesse-Darmstadt, stretching northwards from Heidelberg to Darmstadt. Its length is about 45 miles; and the highest point is the Katzenbuckel, 2300 feet above the sea. The western slopes consist of granite and gneiss, and the eastern of sandstone. The higher elevations are well wooded, and the lower regions cultivated. Several remains of Roman forts exist here.

ODER, a river of Europe, rises in Moravia, about 15 miles E. of Olmütz, flows N.E. to the confines of Prussia, then turns to the N.W., and flows generally in that direction as far as Oderberg in Brandenburg, where it turns to the N.E., and discharges its waters through the Grosse Haff into the Baltic. Its whole length is 550 miles; and it is navigable for vessels of 50 tons as far as Breslau, and for small boats up to Ratibor in Prussian Silesia. It receives from the right the Malapane, Bartsch, and Wartha; and from the left the Oppa, Silesian and Bohemian Neisse, Katzbach, and Bober. The principal towns on its banks are Breslau, Glogau, Frankfort, Custrin, and Stettin. This river is connected by canals with the Elbe, the Spree, and the Vistula.

ODESSA, a town of European Russia, in the government of Kherson, stands on the north-western shore of the Black Sea, 90 miles W.S.W. of Kherson, and 390 N. of Constantinople; N. Lat. 46. 28., E. Long. 30. 43. Placed between the mouths of the Dniester and Bug, and not far from that of the Dnieper, the site is very favourable for commerce.

From the reign of Peter the Great, Russia had been steadily looking forward to a maritime preponderance, both

Odessa.

military and commercial, in the Black Sea; and soon after the peace of Jassy, by which the province of Kherson was ceded to Catharine, that princess selected as the place for a commercial emporium a village called Kodschabeg, then inhabited only by a few fishermen. The town was founded in 1794; and the first settlers were a number of Greek families, who were induced to remove thither from other portions of the country which had been recently given up by the Turks. When the Emperor Alexander I. ascended the throne, he entered with zeal into the project which Catharine had formed. The French emigrant Duke of Richelieu, who had entered the Russian service, was appointed governor, and displayed great zeal and judgment. Under his administration Odessa rapidly rose in prosperity; so that by the year 1804 the inhabitants had increased to the number of 15,000. A fortress, a lighthouse, and a lazaretto, were constructed, as well as a mole to secure 300 sail of vessels from the S.W. winds, which sometimes blow with prodigious force. In 1817 the inhabitants were exempted from taxes for thirty years; and the port was declared to be an open one. All goods of every kind could now be imported without duty for the consumption of the city, or for re-exportation, but were chargeable with duty on passing into the surrounding country. This gave a great impetus to its advancement, which still operates. During the late Russian war the batteries of Odessa fired upon the Furious, a British steam-frigate under a flag of truce, on the 14th of April 1854; and as no reparation was made for this breach of the laws of war, a squadron of the allied fleet bombarded the place on the 22d of April, and greatly injured the fort, the batteries on the moles, and the vessels in the harbour. On the 12th of May the steam-frigate Tiger, which ran aground in a fog, was fired at by the artillery of Odessa. The vessel was destroyed, the captain mortally wounded, and the crew captured.

The prosperity of Odessa has risen in a great measure from its maritime accessibility. It has a spacious bay, which, though open to the easterly winds, is tolerably secure; it is very extensive, and the anchorage ground is good. There is a kind of harbour formed by two moles, about two-thirds of a mile in length, and a handsome quay capable of accommodating 300 vessels. The town is regularly built; the streets are wide and straight; and the houses are for the most part built of stone, and two stories in height. The streets are, however, but partially paved. Odessa is defended by a strong citadel on the N.E., which has a double ditch and also several outworks; and there are also batteries on the moles and on the shore between them. Among the public edifices, the most conspicuous is the cathedral, a large and elegant pile. There are a number of other churches for the Greek worship; and the Jews, Roman Catholics, and German Lutherans have their respective places of worship. A college has been established, with a museum and botanic garden. The admiralty, hospital, exchange, and theatre (where plays, in the Russian and Greek languages, and Italian operas, are performed), are fine buildings. The town has several schools, a lazaretto, barracks, and the governor's house, containing the public offices. Along the quay runs a boulevard, lined with handsome houses, and adorned with a statue of Richelieu. Most of the water is brackish; and to provide that necessary element in purity, an aqueduct has been constructed at great expense, which conveys it from a distance of nearly 20 miles. The climate is healthy, though the summer is intensely hot. Winter is short, but severe, the sea being more or less frozen for about two months.

The rapid growth of Odessa depends wholly upon its commerce, the sources of which are to be found in the fertility of its surrounding soil and that of the more distant districts, to which there is easy access. The steppes, which form a semicircle around Odessa, extend to nearly 100 miles from the city. This district is destitute of trees and of running water, but the soil is said to be favourable to the growth of corn, especially of wheat. There are many gardens and vineyards in the vicinity of Odessa; and the melons raised here form a favourite article of food.

Odiham ‖ Odoacer.

The soil of the districts bordering upon the northern side of the steppes, even with the negligent husbandry it receives, is most abundantly productive of wheat. Indeed, there is no part of the world known in which, in propitious seasons, the increase of grain is so great. It is, however, liable to great variations in its growth, and sometimes years occur when the increase is very insignificant. The quantities of wheat exported from Odessa in each year from 1847 to 1852 may be seen from the following table:—

Years.	Qrs.	Years.	Qrs.
1847	2,016,692	1850	980,377
1848	1,409,963	1851	718,325
1849	1,127,000	1852	1,362,251

The quantity of Indian corn exported in 1852 was 225,635 qrs.; of rye, 216,229 qrs.; of barley, 35,102 qrs.; of oats, 6918 qrs.; and of pulse, 4291 qrs. The corn of Odessa is for the most part conveyed to the coasts and islands of the Mediterranean, and also in large quantities to Britain, to which there were exported from this place in 1852, 570,237 qrs. of wheat, 222,276 of Indian corn, 3644 of rye, 23,875 of barley, 1296 of oats, and 404 of peas. Of linseed there were exported in 1852, 135,880 qrs.; of tallow, 38,575 cwt.; of candles, 5688 cwt.; of wool of various sorts, 74,864 cwt.; of hides, raw and dressed, 1877 cwt.; of copper, 8133 cwt.; and of cables and cordage, 13,227 cwt. To the United Kingdom were exported, in 1852, 83,050 qrs. of linseed, and 16,450 cwt. of wool, besides smaller quantities of other articles. The total value of the exports from Odessa was estimated in 1852 at L.3,976,754. The imports consist chiefly of wine, porter, rum, sugar, tobacco, fruits, lead, tin, zinc, coals, hardware, machinery, and linen, woollen, silk, and cotton goods. The total value of the articles imported in 1852 was estimated at L.1,637,895. The number of vessels that entered the port in 1851 was 698, and the tonnage 196,218, including 126 British vessels, with a tonnage of 37,531. The number that cleared was 729; tonnage, 203,842; and among these, 130 British, tonnage, 38,830.

The inhabitants are of very mixed races, but consist chiefly of Russians, Greeks, and Jews. German handicraftsmen are also to be found amongst them in considerable numbers; whilst the more extensive mercantile houses are composed of Italians, English, French, or Armenians. In no spot perhaps in Europe are there so great a number of languages spoken as on the exchange of Odessa. The admixture of oriental dresses, manners, and languages presents a very novel and lively picture; and the bazaars contain all the productions of the East, from Persian shawls down to rose-pastilles. Pop. (1850) 71,392.

ODIHAM, a market-town of Hampshire, England, 37 miles N.E. of Southampton. It stands on the N. side of a chalk down, and consists of a well-built main street and two others of smaller size. The parish church is an old brick edifice, with a square tower. There are remains of an ancient palace, and a ruined castle in which David I. of Scotland was imprisoned for eleven years. Lily the grammarian was born at Odiham in 1468. Pop. (1851) of the parish 2811.

ODIN, the supreme divinity of the ancient Scandinavians. (See MYTHOLOGY.)

ODOACER, the first barbarian king of Italy, was the son of Edecon, the minister of Attila. In 476 he wrested the sceptre from the hands of Romulus Augustulus, the last Roman emperor of the West; and in 493 he was deposed and assassinated by Theodric the Ostrogoth. (See ITALY.)

ODONTOLOGY.

INTRODUCTION.

Introduction. Definition.

ODONTOLOGY[1] is that branch of anatomical science which treats of the teeth. The term "tooth" has been applied in Zoology and Zootomy to various organs and parts; usually to such as are so solid, so shaped, and so situated in animal bodies, as to serve for seizing and operating on the food; but it has been also applied to parts, such as the prominences on the hinge of bivalve shells, which have no relation to the digestive function. The silicious spines of infusory animalcules, the calcareous jaws of sea-urchins, the chitinous hooks and hooklets of sea-worms, and many corresponding parts of invertebrate animals, are described as "teeth;" but the present essay exclusively relates to those bodies, hardened chiefly by the phosphate of lime, which are attached to parts of the mouth or beginning of the alimentary canal, and which are peculiar to the vertebrated classes of animals.

The term "tooth" is immediately derived from the Teutonic word *tunth*, which we may trace through the old English or Anglo-Saxon *tain*, the Danish *tand*, the German *zahn*, the Latin *dens*, the French *dent*, the Italian *dente*, the Greek *odous*, *odontes*, the Welsh *dant*, the Erse *dend*, and the Lithuanic *dantis*, to the Sanscrit mother-root *dantas:* these synonymes being strikingly illustrative of the coincidence, in one of the primary words, of a natural class of languages which prevails from Central Asia, westward, over Europe, and of the unity of stock of the great Indo-European family of mankind.

True calcified teeth are primarily, if not permanently, distinct parts from the bony skeleton, and are exposed, save where their development is prematurely arrested, as, *e.g.*, in the rudimental tusk of the narwhal. The exceptions to their calcified condition in the Vertebrata are very few; such, *e.g.*, as the horny teeth in the Myxinoid fishes and the Monotremes. But true calcified teeth vary in their tissue and composition, and still more in regard to number, size, form, structure, position, and mode of attachment in different animals. They are principally adapted for seizing, tearing, dividing, pounding, or grinding the food: in some they are modified, to serve as weapons of offence and defence; in others as aids to locomotion, means of anchorage, instruments for uprooting or cutting down trees, or for transport and working of building materials. They are characteristic of age and sex; and, in man, they have secondary relations subservient to beauty and to speech.

Teeth are always most intimately related to the food and habits of the animal, and are therefore highly interesting to the physiologist. They form, for the same reason, most important guides to the naturalist in the classification of animals; and their value as zoological characters is enhanced by the facility with which, from their position, they can be examined in living or recent animals; whilst the durability of their tissues renders them not less available to the palæontologist in the determination of the nature and affinities of extinct species, of whose organization they are often the sole remains discoverable in the deposits of former periods of the earth's history.

Teeth are composed of a cellular and tubular basis of animal matter containing earthy particles, a fluid, and a vascular pulp. In general, the earth is present in such quantity as to render the tooth harder than bone, in which case the animal basis is gelatinous, as in other hard parts where a great proportion of earth is combined with animal matter. In the very few instances among the vertebrate animals above cited, where the hardening material exists in a much smaller proportion, the animal basis is albuminous; the teeth here agree, in both chemical and physical qualities, with horn.

Introduction. Composition.

Teeth rarely consist, like bones, of a uniform or nearly uniform substance, but are composed to two or more tissues, characterized by the proportions of their earthy and animal constituents, and by the size, form, and direction of the cavities in the animal basis which contain the earth, the fluid, or the vascular pulp. The tissue which forms the body of the tooth is called "dentine" (Lat. *dentinum;* Germ. *zahnbein, zahnsubstanz;* Fr. *l'ivoire*); (fig. 1, *d*). The tissue which forms the outer crust of the tooth is called "cement" (Lat. *cæmentum, crusta petrosa*); (figs. 1 and 5, *c*). The third tissue, when present, is situated between the dentine and cement, and is called "enamel" (Lat. *encaustum, adamas*); (figs. 1 and 5, *e*).

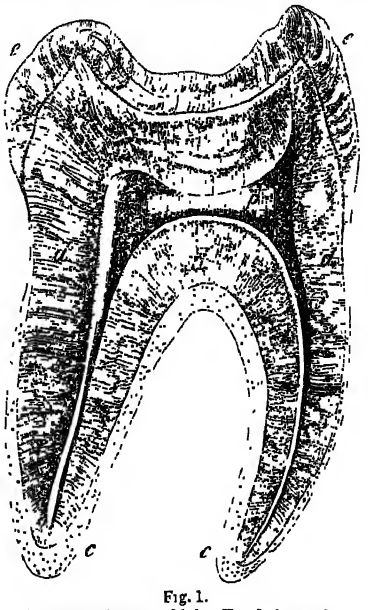

Fig. 1.
Section of Human Molar Tooth (magn.).

Dentine consists of an organized animal basis, and of earthy particles: the basis is disposed in the form of compartments (fig. 3, *a*), of minute tubes (fig. 3, *d*), and cells (fig. 3, *g*); the particles have a twofold arrangement, being either blended with the animal matter of the interspaces (*c*) and parietes (*d*) of the tubes and cells, or being contained in a minutely granular state in their cavities. The density of the dentine arises principally from the proportion of earth in the former of these states of combination. The tubes and cells contain, besides the granular earth, a colourless fluid, probably "plasma," or "liquor sanguinis," in a delicate cellular tissue, and thus relate not only to the mechanical conditions of the tooth, but to the vitality and nutrition of the dentine.

Approximative steps to the recognition of the true nature of teeth were made by Purkinjé[2] and Retzius;[3] but the first definite and unequivocal announcement of the observed organic connection between the vascular and vital soft parts of the frame and the hard substance of a tooth, was communicated to the Institute of France in 1839.[4] "If the

[1] From *ὀδους*, a tooth, and *λογος*, a discourse.

[2] *De penitiori Dentium Humanorum structurâ Observationes* (Fraenkel), and *Meletemata circa Mammalium Dentium Evolutionem* (Rashkow), 4to, 1835.

[3] *Mikroskopiska Undersökningar öfver Jädernes särdeles Tandbenets struktur*, Stockholm, 1837.

[4] "Mais si un bulbe, dans ces conditions, est sousmis au microscope, et comparé à un bulbe encore dépourvu de matière calcaire, on voit qu'il n'est plus revêtu de la membrane lisse, dense, que l'on observe dans ce dernier; et le bord apical du bulbe dont on a détaché son étui émaillé parâit villeux et flocconeux." . . . . "A mesure que la formation de la dent est plus avancée, il devient plus difficile de séparer la portion calcifiée du bulbe de la portion non calcifiée, et en même temps plus facile de découvrir la continuation des pro-

Introduction.

Nature of tooth.

pulp of a growing tooth be submitted to microscopical examination, and compared with a pulp before it has begun to be calcified, it will be seen to be not covered by any outer membrane, like the so-called 'membrana propria,' or the smooth dense covering of the uncalcified pulp; but the surface of the pulp, from which the calcified sheath has been removed, will appear cottony and villous: in proportion as the tooth is more advanced in its formation, it becomes more difficult to separate the calcified from the non-calcified part of the pulp, and at the same time more easy to discover the continuation of the prolongations of the pulp in the interior of the numerous medullary canals which constitute so many distinct centres of radiation for the plexiform dentinal tubes." This discovery of the organic connection between the pulp and the canals of the dentine, made by observation of the development of the teeth of the shark, was affirmed to be applicable to the teeth of Mammalia: it was only the excessive smallness of the dentinal tubes in the latter which rendered invisible to the naked eye the irregularity of the uncalcified surface of the pulp, when the calcified part was detached in a growing tooth. The apparent smoothness of such exposed surface was illusory.

Dr Schwann, in his important essay on the correspondence in structure and development between animals and plants,[1] spoke of the "presumed" transition of the cells of the pulp into the dentinal tubes, which he calls "fibres," but leaves that capital fact as one still of uncertainty, and questionable. The author of the present article published the full evidence of his original propositions, above cited, in his work entitled *Odontography*, 4to, 1840–1845, and was able to give more direct testimony of the continuation of filamentary processes of the pulp into the minute tubes of hard dentine, on the occasion of anatomizing a full-grown male elephant in 1850. "I had the tusk and pulp of the great elephant at the Zoological Gardens longitudinally divided, soon after the death of that animal in the summer of 1847. Although the pulp could be easily detached from the inner surface of the pulp-cavity, it was not without a certain resistance, and when the edges of the co-adapted pulp and tooth were examined by a strong lens, the filamentary processes from the outer surface of the pulp could be seen stretching, as they were withdrawn from the dentinal tubes, before they broke. They are so minute that, to the naked eye, the detached surface of the pulp seems to be entire, and Cuvier was thus deceived in concluding that there was no organic connection between the pulp and the ivory."[2]

Confirmatory evidence of the continuation of filamentary processes of the pulp into the dentinal tubuli in the human teeth, has recently been communicated to the Royal Society of London by Mr Tomes.[3] It has appeared to the present writer that the filamentary processes of the pulp become resolved, at or near the first bifurcation of the tubuli, into mere delicate membranous linings of the dentinal tubes, which are chiefly occupied by the plasma contained in these continuations of the pulp, with occasional detached calcareous particles.

Introduction.

Until a comparatively recent period, the analogy of dentine to bone was supposed to be confined to their chemical constitution, and the nature of the hardening material; while the arrangement, as well as the mode of deposition of the tooth-tissue, were considered to be wholly different from that of bone; and the dentine to agree, in its general nature and mode of growth, with hair and other extravascular horny parts, with which most teeth closely correspond in their vital properties.[4]

Structure.

The structure of a tooth, in fact, was regarded as simply laminated, and the ivory was described as being formed layer within layer, deposited by, and moulded upon, the formative superficies of the vascular pulp. The illustrations and supposed proof of this structure and mode of growth were derived from the apparently detached condition of the newly-formed particles of dentine on the pulp's surface, when exposed by the removal of the calcified part of the tooth; from the appearance observed in the teeth of animals fed alternately with madder and ordinary food, which undoubtedly illustrate the true progress of dental development; from the illusory traces of laminated structure observed in vertical sections of teeth when viewed with the naked eye, or with a low magnifying power; and lastly, and chiefly, from the successive hollow cones into which a large tooth, such as the elephant's tusk, is commonly resolved in the process of decomposition.

With regard, however, to the appearances presented by the teeth of animals under the influence of madder, and the separation of the dentine into superimposed lamellæ during decomposition, the same conclusions, as to intimate structure and mode of development, might be drawn respecting true bone, which also commonly resolves itself into the concentric lamellæ during decomposition, and presents the same appearance of alternate white and red layers in animals fed alternately with madder and ordinary food during the progress of its growth. The lines running parallel to each other, and to the contour of the crown, presented by the cut surfaces of vertical sections of teeth, especially of the elephant's tusk, or of the tooth of the cachalot, are due to a totally different structure from that to which they are ascribed. The lamellated arrangement, thus seemingly demonstrated, is, moreover, far from being a constant appearance; on the contrary, the superficies of vertically cut or fractured surfaces of the human and most other teeth offer a very different character, and one which has led to many approximations and allusions to the true structure of dentine, in the works of anatomists who have recorded their own original observations.

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longements du bulbe dans l'interieur de ces nombreux canaux médullaires qui constituent tant de centres de radiation distincte pour les tubes calcigères plexiformes. Le principe du dévelopment dentaire s'effectuant par *dépôt dans la substance* et non par *exsudation en dehors de la substance* d'un bulbe pré-existant, tel qu'il ressort de la dentition des squales, est d'une application sans effort, naturelle et manifeste à la formation des dents des mammifères. Dans l'ivoire d'une dent simple de mammifère, il existe un canal médullaire unique, appelé cavité du bulbe, et un système unique de tubes rayonnés calcigères; mais le plan et la mode de formation sont les mêmes que dans les squales." "Les tubes calcigères d'une dent de mammifère cnt des parois distinctes tant dans les portions calcifiées que dans les portions non calcifiées du bulbe. Ces parois sont rendues fragiles par le dépôt qui s'y fait de particules terreuses dans la portion calcifiée du bulbe, et alors se separent facilement de leur portion non calcifiée, laquelle se continue dans le reste du bulbe, et c'est l'excessive petitesse des tubes rompus qui rend invisible à l'œil nu l'irregularité de la surface du bulbe: mais cette appearance d'une surface naturelle libre, exsudante, n'est qu'une illusion." (*Recherches sur la structure et la formation des dents des Squaloïdes, et application des faits observés à une nouvelle théorie du développement des dents*, par M. R. Owen; *Comptes Rendus des Séances de l'Academie des Sciences*, No. 25, 16 Décembre 1839, p. 786.

[1] *Mikroscopische Untersuchungen ueber die Uebereinstimmung in der Struktur und dem Wachsthum der Thiere und Pflanzen*, 8vo, 1839, p. 117.

[2] *Cyclopædia of Anatomy and Physiology*, p. 929, part xxxviii., Feb. 1850. Compare with *Annales du Muséum*, tom. viii., p. 96, and the *Ossemens Fossiles* of Cuvier, tom. i., p. 517, ed. 1834–6.

[3] *Philosophical Transactions*, 1856, p. 515.

[4] See English translation of Müller's *Physiology*, 1837, pp. 391 and 392; De Blainville, *Ostéographie et Odontographie*, Primates, p. 15, without date, but communicated by the author to the Institute of France, December 1839; vide *Comptes Rendus de l'Academie* of that month, Dec. 16, p. 782.

Introduction. Structure.

Whoever attentively observes a polished section or a fractured surface of a human tooth, may learn, even with the naked eye, that the silky and iridescent lustre reflected from it in certain directions is due to the presence of a fine fibrous structure.

Malpighi, in whose works may be detected the germs of many important anatomical truths that have subsequently been matured and established, says, that the teeth consists of two parts, of which the internal bony layers (dentine) seem to be composed of fibrous, and, as it were, tendinous capillaments reticularly interwoven.[1] Retzius cites many recent authors—*e.g.*, Sœmmering, Schreger,[2] and Weber[3]—who mention the silky, glistening lustre of the dentine; and Frederick Cuvier, in the preliminary discourse of his admirable work, the *Dents des Mammifères*, observes, "Les dents de l'homme, de singes, de carnassiers, ont un ivoire d'apparance soyeuse, qui semble formé de fibres" (p. 27). These intelligible hints of the true structure of the dentine, which the foregoing observers received from a superficial but unprejudiced inspection, failed, however, to incite them to a closer interrogation of nature in regard to the dental tissues. One of her most persevering investigators had, nevertheless, long before obtained a true and definite answer to his more direct inquiries. Leeuwenhoek having applied his microscopical observations to the structure of the teeth, discovered that the apparent fibres were really tubes, and he communicated a brief but succinct account of his discovery to the Royal Society of London, which was published, together with a figure of the tube, in the 140th number of their *Transactions*. This figure of the dentinal tubes, with additional observations, again appears in the Latin edition of Leeuwenhoek's Works, published at Leyden in 1730. The dental substance (dentine) of the human teeth, and of those taken from young hogs, is described as "being formed of tubuli spreading from the cavity in the centre to the circumference."[4] Fig. 2 is accurately copied from Leeuwenhoek's original figure, intended to represent the general arrangement of these tubuli in the human molar tooth. The Dutch microscopist computed that he saw 120 of the tubuli within the forty-fifth part of an inch.[5] Leeuwenhoek also shows that he was aware of the peculiar substance, distinct from the ivory and enamel, and now termed the cement, or *crusta petrosa*, which enters into the composition of the teeth of the horse and ox;[6] a component part of the tooth which Hunter speaks of as a second kind of bone, and which was first accurately and specifically described by Tenon[7] and Blake.[8]

Fig. 2. Section of Human Molar Tooth; after Leeuwenhoek.

The discovery of Leeuwenhoek that the dentine was made up of very minute tubes, which proceeded from the inner to the outer surface of the tooth, was confirmed by Purkinjé[9] so far as regarded their existence; but Purkinjé added an exact and particular account of the direction of these tubes in the human dentine, and showed that, in addition to them, the dentine contained an intermediate or intertubular tissue. This he describes as homogeneous and without structure, and as entering into the composition of the dentine in a greater proportion than the tubes themselves. The more extensive, varied, and minute observations of Professor Retzius[10] led to the discovery of the cells of the intertubular tissue of the ramuli (fig. 3, *f*), sent

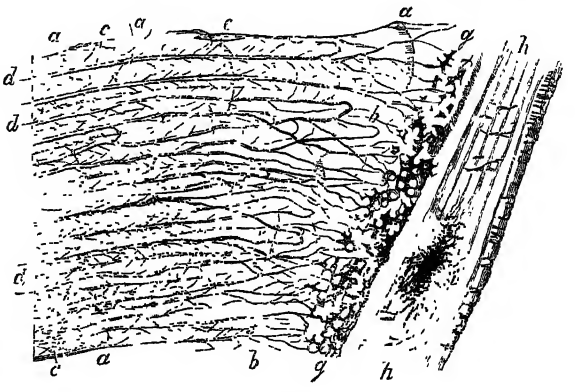

Fig. 3. Highly-magnified section of Dentine and Cement, from the Fang of a Human Molar Tooth.

off from the main dentinal tubes (fig. 3, *d*), into that tissue, and of the anastomoses of the ramuli with each other (fig. 3, *b*), with the intertubular cells, and with the cells at the periphery of the dentine (fig. 3, *g*). According to the researches of Dr Schwann,[11] the animal basis of the intertubular tissues possesses a fibrous structure. Besides the primary and secondary branches of the dentinal tubes, Retzius first clearly described their curvatures and undulations, which may be defined as follows:—As a general rule, the dentinal tubes are directed, as affirmed by Leeuwenhoek and Purkinjé, from the inner to the outer surface of the tooth, and vertically to those surfaces, as shown in the section of the human incisive tooth (fig. 4), and of the molar tooth (fig. 1, at *d*, *d*). But in their course the tubes describe two, three, or more curvatures, appreciable by a low magnifying power. These are termed the "primary curvatures."[12] With a higher power, the tubes are seen to be bent throughout the whole of their flexuous course into minute and oblique undulations or gyrations (fig. 3, *d*), 200 of which were counted by Retzius in one-tenth part of an inch length of a human dentinal tube; these are termed the "secondary curvatures" or gyrations.[13] Both the primary and secondary curvatures of one dentinal tube are usually parallel with those of the contiguous tubes; and from the radiated course of these tubes, they occasion the appearance of lines running parallel with the ex-

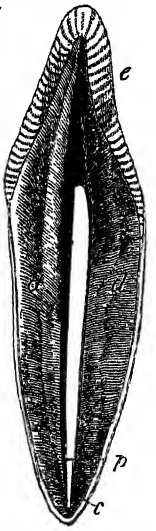

Fig. 4. Section of Human Incisor.

[1] "Duplici excitantur parte, quarum interior ossea lamella fibrosis et quasi tendinosis capillamentis in naturam implicetis constat." (*Anatome Plantarum*, Lugd. Batav. 1687, p. 37.)

[2] Isenflamm und Rosenmüller's *Beiträgen zur Zergliederungskunst*, band i., p. 3 (1800).

[3] See his edition of Hildebrand's *Handbuch der Anatomie*, band i., p. 206.

[4] "Microscopical Observations on the Structure of Teeth and other Bones (*Philosophical Transactions*, 1678, p. 1002).

[5] See Hoole's translation of the *Select Works* of Leeuwenhoek, 4to, 1798, p. 114.

[6] "Parvi molares, quos bos, dum adhuc admodum juvenis sive vitulus, habuerat, undiquaque *alio osse* circumducti erant." (*Continuatio Epistolarum*, 4to, Lugd. Bat. 1689, p. 7.)

[7] "Mémoire sur une Méthode particulière d'etudier l'Anatomie," in *Mémoires de l'Academie des Sciences*, Paris, an. vi.

[8] *An Essay on the Structure and Formation of Teeth*, Dublin, 1802.

[9] *De penitiori Dentium Humanorum structura Observationes*, 4to, 1835.

[10] *Mikroskopiska Undersökningar öfver Jädernes särdeles Tandbenets struktur*, 8vo, Stockholm, 1837.

[11] *Microskopische Untersuchungen über die Uebereinstimmung in der Strucktur der Thiere und Pflanzen*, 8vo, 1839.

[12] *Trans. Brit. Assoc.*, vol. vii., p. 148. See *Odontography*, plate 24, fig. 1; 64 A, fig. 2; 74, fig. 1; 94.

[13] *Odontography*, p. 141; see plates 16, fig. 3; 24, fig. 2; 64 A, fig. 3.

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ternal contour of the tooth; for, when the surface of a longitudinal section of a tooth is viewed with the naked eye, the light is differently reflected from the different parts of the oblique secondary curves of the tube on which it falls; but the curves being parallel to each other, and to the superficial contour of the section, they appear like the cut edges of a series of parallel and superimposed lamellæ. In many teeth, moreover, and especially in the tusks of the elephant, the secondary branches of the dentinal tubes dilate into intertubular cells; along lines which, in like manner, are parallel to the coronal contour of the tooth: hence another cause of the appearance of concentric lamellæ, and of the actual decomposition of such teeth into superimposed lamelliform cones. Such appearances and modes of decomposition are peculiar to the dense or unvascular dentine, but are by no means common to that modification of the tissue. Varieties of form, such as the occasional aneurismal-like dilatations of the dentinal tubuli, as shown at *e* (fig. 3), have been figured by that accurate and minute investigator of the pathology of the human teeth, Mr S. J. A. Salter, in the *Transactions of the Pathological Society of London* for 1855, pl. i., fig. 3. In fig. 3 the delicate filamentary prolongations of the pulp are represented at *d, d;* the dentinal compartments, or indications of the original cells of the dentinal pulp are shown at *a, a;* and the modified peripheral layer of the dentine at *g*, to the superior sensibility of which M. Duval first called attention, distinguishing it by the name of "dictyodonte."[1]

Such is the typical structure of dentine, which structure relates, in regard to the curvilinear compartments, *a, a* (fig. 3), to the steps in its formation; and in regard to its tubular columns, to the strength of the tooth and its vitality; the latter important property depending on the percolation of the plasma through the delicate cellular structure of the filamentary prolongations of the pulp, so far as they may extend along the tubuli. The sensibility of the dentine is due to concomitant productions of neurine; but the distinct tubules are not large enough to admit capillary vessels with red particles of blood, and the tissue above described has consequently been sometimes termed "unvascular dentine."

The simplest modification of dentine is that in which capillary tracts of the primitive vascular pulp remain uncalcified, and permanently carry red blood into the substance of the tooth. These so-called medullary canals (more properly "vascular canals"), present various dispositions in the dentine, which they modify, and which modification is called "vasodentine."[2] It is often combined with true dentine in the same tooth; *e.g.*, in the scalpriform incisors of certain rodents,[3] the tusks of the elephant,[4] the molars of the extinct iguanodon.[5] A third modification of the fundamental tissue of the tooth is where the cellular basis of the dentine is arranged in concentric layers around the vascular canals, and contains radiated cells like those of osseous tissues; it is called "osteodentine."

The tissue called "cement" closely corresponds with osteodentine and with the osseous tissue of the skeleton of the same animal in which it is found; and wherever it occurs of sufficient thickness, as upon the teeth of the horse (fig. 5, *c*), sloth (fig. 9, *c*), or ruminant, it is also traversed, like bone, by vascular canals. In reptiles and mammals, in which the animal basis of the bones of the skeleton is excavated by minute radiated cells, forming with their contents the "corpuscles of Purkinjé," these are likewise present, of similar size and form, in the "cement;" and are its chief characteristic as a constituent of the tooth. The hardening material of the cement is partly segregated and combined with the parietes of the radiated cells and canals; and is partly contained in disgregated granules in the cells, which are thus rendered white and opaque viewed by reflected light.

Fig. 5.
Highly-magnified Section of part of a Horse's Tooth.

The relative density of the dentine and cement varies according to the proportion of the earthy matter, and chiefly of that part which is combined with the animal matter in the walls of the cavities, as compared with the size and number of the cavities themselves. In the complex grinders of the elephant (fig. 140), the wart-hog (fig. 121), the voles (fig. 88), and the capybara, the cement *c*, which forms nearly half the mass of the tooth, wears down sooner than the dentine.

The "enamel" is the hardest constituent of a tooth, and consequently the hardest of animal tissues; but it consists, like the other dental substances, of earthy matter arranged by organic forces in an animal matrix. Here, however, the earth is mainly contained in the canals of the animal membrane; and, in mammals and reptiles, completely fills those canals which are comparatively wide, whilst their parietes are of extreme tenuity. The hardening salts of the enamel are not only present in far greater proportion than in the other dental tissues; but in some animals are peculiarly distinguished by the presence of a small proportion of fluate of lime.

The examples are extremely few, and confined to cold-blooded animals, of calcified teeth which consist of a single tissue; and this is always a modification of dentine. The maxillary denticles of the parrot-fish (*Scarus*), and the large pharyngeal teeth of the wrasse (*Labrus*), consist of a very hard kind of unvascular dentine. Fig. 6 shows a vertical section of one of the latter teeth, supported upon the vascular osseous tissue of the pharyngeal bone; *p* is the pulp cavity.

The next stage of complexity is where a portion of the dentine is modified by vascular canals. Teeth thus composed of dentine and vaso-dentine are very common in fishes. The hard dentine is always external, and holds the place, and performs the office, of enamel in the teeth of

[1] *Observations Anatomiques sur l'Ivoire*, 8vo, Paris, 1838, p. 14. "Souvent les molaires sont tellement usées que, au lieu d'etre tuberculeuse, leur face triturante est lisse par l'effet de la détrition. On y distingue parfaitment, comme après la coupe transversale d'une dent, les aspects sous lesquels se presentent ses substances dures; l'un appartient à l'émail qui est tres-blanc; le second à la substance osseuse, que je désigne sous le nom *d'osteodonte;* et le troisième à cette partie qui, sous forme de zone circulaire et de couleur de corne, se trouve entre ce dernier et l'émail, et que j'appelle *dictyodonte*. Si avec la pointe d'un curedent d'acier, ou d'une sonde, on touche une de ces parties, l'émail ne donne aucun signe de sensibilité, l'osteodonte quelquefois un peu, mais le dictyodonte beaucoup et plus souvent. (Duval, *Observations Pratiques sur la Sensibilité des Dents*, 8vo, 1833, p. 7.)

[2] This substance was first characterized as a component of tooth distinct from ivory, enamel, cement, and true bone, and as easily recognisable, in a paper by the author, communicated to the British Association in 1838, *loc. cit.* p. 137.

[3] *Odontography*, 4to, p. 405.

[4] Ibid., p. 643.

[5] Ibid., p. 251.

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higher animals.[1] Fig. 7 illustrates this structure in a longitudinal section of a tooth of a shark of the genus *Lamna*; in the outer layer of hard unvascular dentine, the earthy constituent so predominates that it takes a polish like enamel,

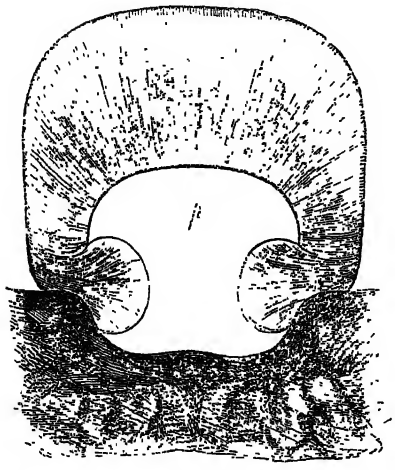

Fig. 6.
Magn. section of a Pharyngeal Tooth of *Labrus*.

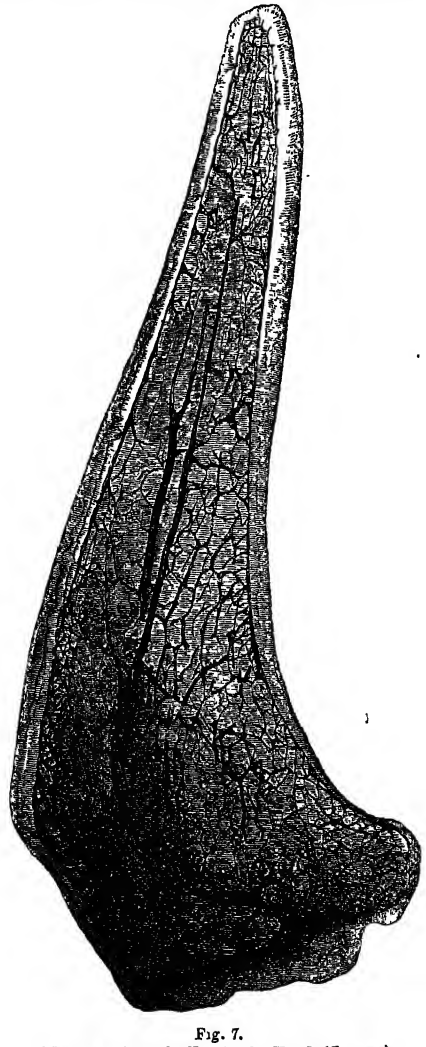

Fig. 7.
Magn. section of a Tooth of a Shark (*Lamna*).

for which it has commonly been mistaken in the teeth of fishes; it is called "vitrodentine."

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The molars of the dugong are examples of teeth composed of dentine and cement; the latter tissue forming a thick external layer. Fig. 8 shows a transverse section of

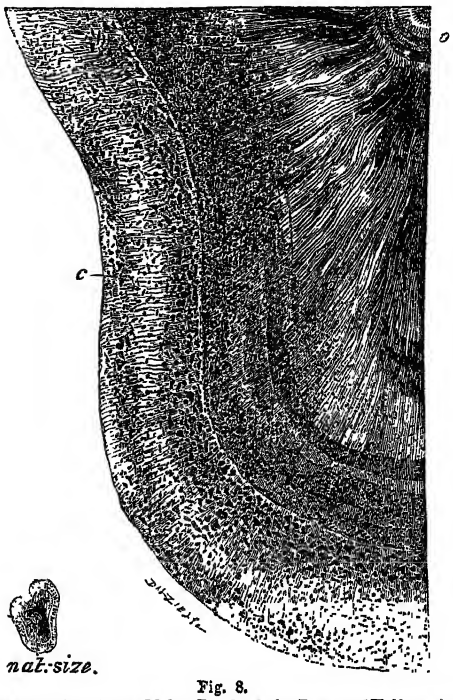

Fig. 8.
Magn. section of part of a Molar Tooth of the Dugong (*Halicore indicus*).

the crown of the second molar, natural size, and above it a magnified view of a portion of the section; in which *d* is the dentine, remarkable for the number of minute calciferous cells at its periphery, and *c* is the cement. A small portion of osteodentine usually occupies the centre of the crown at *o*. In the large teeth of the lower jaw of the cachalot (*Physeter*) the pulp-cavity of the growing tooth becomes filled up by osteodentine, the result of a modified calcification of the dentinal pulp; and the full-grown tooth presents three tissues, as shown in fig. 62, in which *c* is the thick external cement, *d* the hard dentine, and *o* the osteodentine: the latter is sometimes developed into stalactitic-shaped nodules, loose in the pulp-cavity.

In the teeth of the sloth, and of its great extinct congener the megatherium, the hard dentine is reduced to a thin layer, and the chief bulk of the tooth is made up of a central body of vasodentine, and a thick external crust of cement. Fig. 9 represents a longitudinal section of a lower molar of the three-toed sloth (*Bradypus tridactylus*) magnified; *v* is the vasodentine, *d* is the hard dentine, and *c* is the cement; *p* is the apex of the wide persistent pulp-cavity. In the megatherium the hard dentine, which is the firmest tissue, forms the transverse ridge of the grinding surface (fig. 54, *d*), like the enamel-plates in the elephant's grinder: it has consequently been described to be enamel,[2] but its relation to that tissue is only one of analogy or function.

The human teeth, and those of the carnivorous mammals, appear at first sight to be composed of dentine and enamel only, as they were described to be by the Cuviers,[3] who called them therefore "simple teeth;" but their crowns are originally, and their fangs are always, covered by a thin coat of cement. There is also commonly a small central tract

[1] *Odontography*, pp. 17, 37.
[2] Cuvier, *Ossemens Fossiles*, 4to, tom. v., p. 172.
[3] *Dents de Mammifères*, p. 1; *Leçons d'Anat. Comp.* iv. (1836), p. 199.

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of osteodentine in old teeth. In figs. 1 and 4, magnified

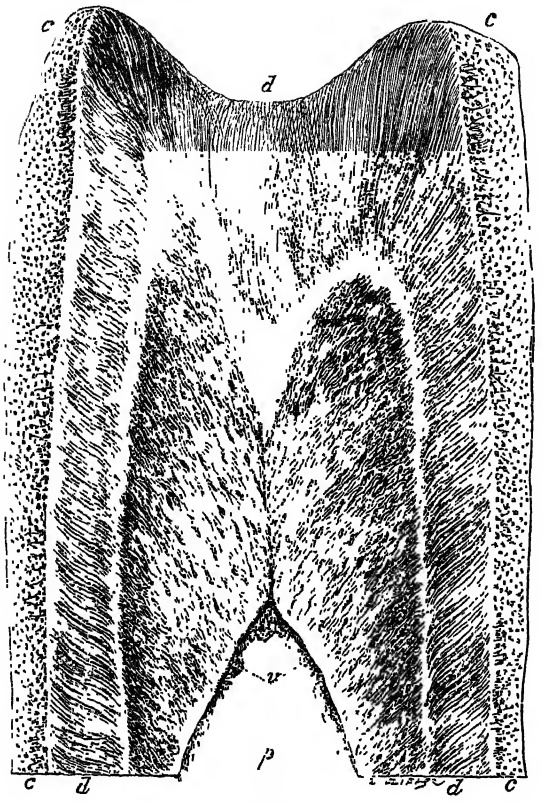

Fig. 9.
Magn. section of a Molar of the Sloth (*Bradypus tridactylus*).

views are given of longitudinal sections of a human incisor and molar tooth, in which *d* is the dentine, *e* the enamel, and *c* the cement.

The teeth called by Cuvier "compound" or "complex" in Mammalia, differ, as regards their composition, from the preceding only by the different proportion and disposition of the constituent tissues. Fig. 10 is a longitudinal section of the incisor of a horse; *d* is the dentine, *e* is the enamel, and *c* the cement; *c'* is the layer of cement reflected into the deep central depression of the crown, usually occupied by a coloured mass of tartar and particles of food, forming the "mark" of the horse-dealer. The characteristic structure of the three tissues—*d* dentine, *e* enamel, *c* cement—is shown in the magnified part of the section in fig. 5.

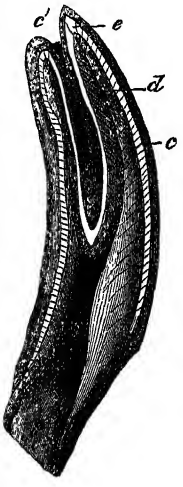

Fig. 10.
Magn. section of part of the Incisor of a Horse.

A very complex tooth may be formed out of two tissues by the way in which they are interblended as the result of an original complex disposition of the constituents of the dental matrix. The teeth of certain fishes, and of a singular extinct family of gigantic sauroid Batrachians, called "Labyrinthodonts,"[1] exhibit, as the name implies, a remarkable instance of this kind of complexity. Fig. 11 is a view of a canine tooth of the *Labyrinthodon salamandroïdes*, of the natural size; and fig. 12 is a slightly magnified view of a transverse section across the part of the crown marked *a*. At first view the tooth appears to be of the simple conical kind, with the exterior surface merely striated longitudinally, but every such streak is a fissure into which the very thin external layer of cement *c* is reflected into the body of the tooth, where it follows the sinous wavings of the lobes of dentine which diverge from the central pulp-cavity *pp*. The inflected fold of cement *c* runs straight for about half a line, and then becomes wavy, the waves rapidly increasing in breadth as they recede from the periphery of the tooth: the first two, three, or four undulations are simple; then their contour itself becomes broken by smaller or secondary waves; these become stronger as the fold approaches the centre of the tooth, when it increases in thickness, and finally terminates by a slight dilatation or loop close to the pulp-cavity, from which the free margin of the inflected fold of cement is separated by an extremely thin layer of dentine. The number of the inflected converging folds of dentine is about fifty at the middle of the crown of the tooth figured, but is greater at the base. All the inflected folds of cement at the base of the tooth have the same complicated disposition with increased extent; but as they approach their termination towards the upper part of the tooth, they gradually diminish in breadth, and consequently penetrate to a

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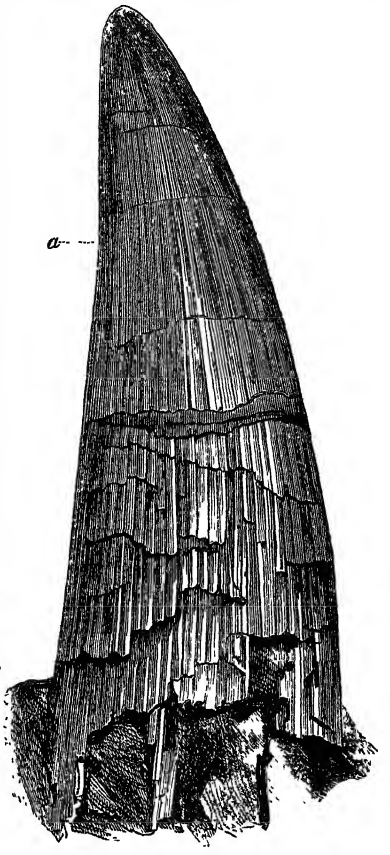

Fig. 11.
Canine Tooth of the *Labyrinthodon salamandroïdes* (nat. size).

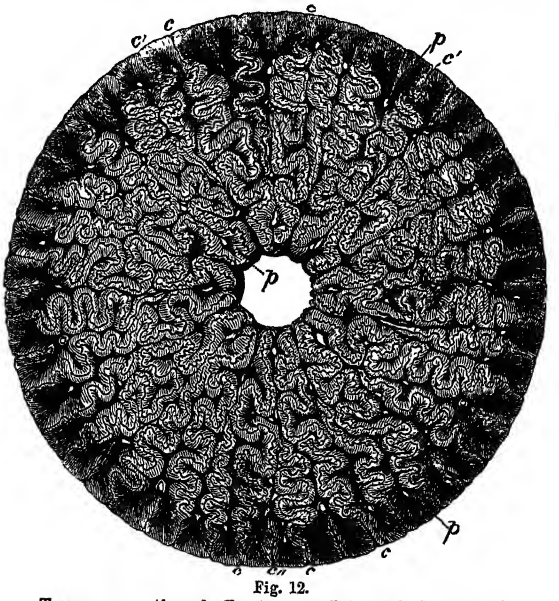

Fig. 12.
Transverse section of a Tooth of the *Labyrinthodon* (magn.)

[1] *Proceedings of the Geological Society*, January 20, 1841, p. 257.

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less distance into the substance of the tooth. Hence, in such a section as is delineated, it will be observed that some of the convoluted folds, as those marked *c*, extend to near the centre of the tooth; others, as those marked *c'*, reach only about half way to the centre; and those folds, *c''*, which, to use a geological expression, are "cropping out," penetrate to a very short distance into the dentine, and resemble in their extent and simplicity the converging folds of cement in the pulp of the tooth of the *Ichthyosaurus*. The disposition of the dentine is still more complicated than that of the cement. It consists of a slender central conical column, excavated by a conical pulp-cavity for a certain distance from the base of the tooth; and that column sends radiating outwards from the circumference a series of vertical plates, which divide into two once or twice before they terminate at the periphery of the tooth. Each of these diverging and dichotomizing plates gives off throughout its course smaller processes, which stand at right angles, or nearly so, to the main plate; they are generally opposite, but sometimes alternate; many of the secondary plates or processes which are given off near the centre of the tooth also divide into two before they terminate, and their contour is seen in the transverse section to partake of all the undulations of the folds of cement which invest and divide the dentinal plates and processes from each other. The dental pulp-cavity is reduced to a mere line about the upper third of the tooth, but throughout its whole extent fissures radiate from it corresponding in number with the radiating plates of dentine. Each fissure is continued along the middle of each bifurcation and process to within a short distance of the line of cement. The pulp-fissure commonly dilates into a canal at the origin of the lateral processes of the radiating plates, before it divides to accompany and penetrate those processes. The main fissures or radiations of the pulp-cavity extend to within a line or half a line of the periphery of the tooth, and suddenly dilate at their terminations into spaces, which in transverse section are subcircular, oval, or pyriform (*p*); the branches of the radiating lines, which are continued into the lateral secondary plates or processes of the dentinal lamellæ, likewise dilate into similar and generally smaller spaces. All these spaces or canals in the living tooth, must have been occupied by corresponding processes of the vascular pulp; they constitute so many centres of radiation of the fine calciferous tubes, which, with their uniting clear substance, constitute the dentine.[1]

An analogous complexity is produced by numerous fissures radiating from a central mass of vasodentine, which more or less fills up the pulp-cavity of the seemingly simple conical teeth of the extinct family of fishes called "Dendrodonts," characterizing the Old Red Sandstone, or Devonian system. Fig. 13 is one of these fossil teeth of the natural size—*a*, a transverse section; and fig. 14 a reduced view of a portion of the same section enlarged twenty diameters. Thus magnified, a central pulp-cavity of relatively small size, and of an irregular lobulated form, is discerned, a portion of which is shown at *p*; this is immediately surrounded by transverse sections of large cylindrical vascular or pulp canals of different sizes; and beyond these there are smaller and more numerous medullary canals, which are processes of the central pulp-cavity. In the transverse section these processes are seen to be connected together by a net-work of smaller vascular canals belonging to a coarse osseous

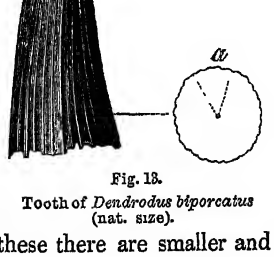

Fig. 13.
Tooth of *Dendrodus biporcatus* (nat. size).

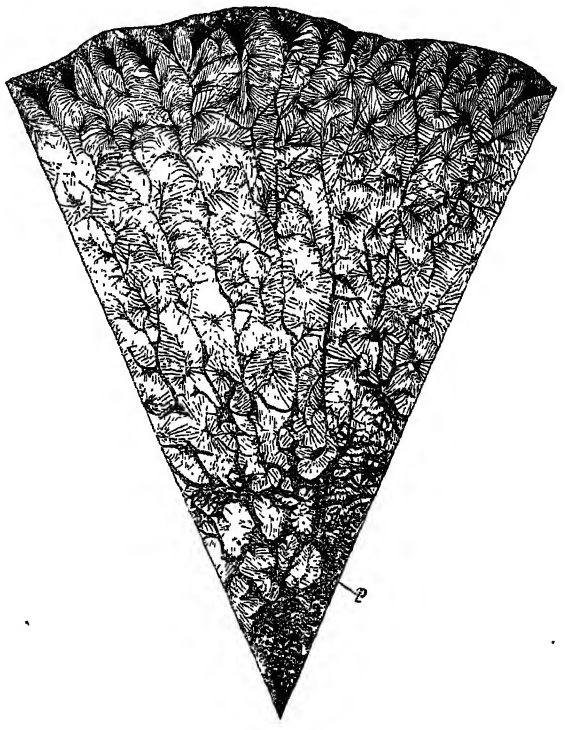

Fig. 14.
Magn. section of part of *Dendrodus biporcatus*.

texture, into which the pulp has been converted, and this structure occupies the middle half of the section. All the vascular canals were filled up by the opaque matrix. From the circumference of the central net-work straight pulp-fissures radiate at pretty regular intervals to the periphery of the tooth; most of these fissures divide once, rarely twice, in their course,—the division taking place sometimes at their origin, in others at different distances from their terminations,—and the branches diverge slightly as they proceed. Each of the above pulp-canals or fissures is continued from a short process of the central structure, which is connected by a concave line with the adjoining process, so that the whole periphery of the transverse section of the central coarse reticulo-vascular body of the tooth presents a crenate outline. From each ray and its primary dichotomous divisions short branches are sent off at brief intervals, generally at right angles with the trunk, or slightly inclined towards the periphery of the tooth. These subdivide into a few short ramifications like the branches of a shrub, and terminate in irregular and somewhat angular dilations simulating leaves, but which resolve themselves into radiating fasciculi of minute dentinal tubes. There are from fifteen to twenty-five or thirty-six of these short and small lateral branches on each side of the medullary rays.

A third kind of complication is produced by an aggregation of many simple teeth into a single mass.

The examples of these truly compound teeth[3] are most common in this class of fishes, but the illustration here selected is from the mammalian class. Each tooth of the Cape ant-eater (*Orycteropus*, fig. 15) presents a simple form; is deeply set in the jaws, but without dividing into

[1] *Odontography*, pp. 195–217, pl. 64 A, 64 B.

[2] Ibid., p. 171.

[3] In the *Leçons d'Anatomie Comparée* of Cuvier, the teeth in which folds of enamel and cement penetrate the entire substance of the crown are called "compound." "Nous appellons dent composée celle dont les differentes substances forment des replis tellement pro-

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fangs; its broad and flat base is porous, like the section of a common cane. The canals to which these pores lead contain processes of a vascular pulp, and are the centres of radiation of as many independent series of dentinal tubules. Each tooth, in fact, consists of a congeries of long and slender prismatic denticles of dentine, which are cemented together by their ossified capsules, the columnar denticles slightly decreasing in diameter, and occasionally bifurcating as they approach the grinding surface of the tooth. A figure of a longitudinal section of the molar teeth is given in pl. 76, fig. 10, of the author's *Odontography*. Fig. 15 gives a magnified view of a portion of the transverse section of the fourth molar, showing *c* the cement, *d* the dentine, and *p* the pulp-cavity of the denticles.

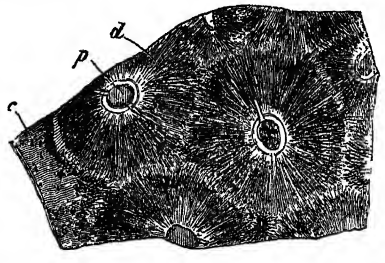

Fig. 15.
Magn. section of a part of the Compound Tooth of the *Orycteropus*.

The pectinated incisors of the flying lemur of the Indian Islands (*Galeopithecus*, fig. 86) are examples of teeth the crowns of which are composed of denticles consisting of hard dentine, with a covering of true enamel. The layer of cement over this is too thin to show its characteristic structure, and does not fill up the intervals of the denticles, which stand out as free processes from the base of the crown. Tubular prolongations of the pulp-cavity are continued up the centre of each denticle. The originally detached summits of the crown of the human incisor are homologous with these columnar processes or denticles of the incisor of the *Galeopithecus*. In the compound molars of the great African wart-hog (*Phacochœrus*), the columnar denticles are in three rows, and their interspaces are filled up by cement; each denticle consists of a slender column of hard dentine inclosed in a thick sheet of enamel, the whole being bound together by the cement; and the denticles, as in the *Galeopithecus*, blend together into a common base in the fully-developed tooth. A figure is given of the grinding surface of the third true molar of the *Phacochœrus Pallasii* in fig. 121.

In the elephant the denticles of the compound molars are in the form of plates, vertical to the grinding surface, and transverse to the long diameter of the tooth (figs. 140, 141). When the tooth is bisected vertically and lengthwise, the three substances—*d* dentine, *e* enamel, and *c* cement—are seen interblended.

A still more complex grinding apparatus is found in certain fishes. The lower pharyngeal bone of the parrot-fish (*Scarus*), for example, supports a dental plate with a triturating surface, like that of the compound molars of the *Phacochœrus*; the interlocked upper pharyngeals (fig. 35) support dental masses with a grinding surface, more like that of the compound molars of the elephant. When a vertical and longitudinal section is made of one of these upper pharyngeal compound teeth, each denticle is seen to be composed of a body of very hard and unvascular dentine, with a thick sheath of enamel, the denticles being united together by the cement, and supported and further united together, and to the pharyngeal bone, by a basal mass of vascular osteodentine. When worn down by the trituration of hard corals to this basis, four alternating kinds of dental tissue, of varying degrees of density, and of corresponding variations of level, are exposed in this fish.[1]

Introduction. Dental tissues.

Such are some of the prominent features of a field of observation which comparative anatomy opens to our view, —such the varied nature, and such the gradation of complexity of the dental tissues, which, up to December 1839, continued, notwithstanding successive approximations to the truth, to be described in systematic works as a "*Phaneros*, or a dead part or product exhaled from the surface of a formative bulb."[2]

Development.

In the development of a tooth, a matrix or formative organ, corresponding in complexity with the kind of tooth to be formed, is first developed. It consists either of a soft vascular papilla,—a free conical process,—as in certain fishes (fig. 24, *c*), which mold of the future simple tooth is called its "pulp," or the "dentinal pulp;" or it consists of the "pulp" inclosed in a "capsule;" or of a pulp with such a modification of a peripheral part, situated between the pulp proper and the capsule, as to merit a distinct definition as an "enamel organ." The first and most constant of these parts is termed the "dentinal pulp" (fig. 16, *p*); the second is the capsule, or "cemental pulp" (fig. 16, *c*); the third is the "enamel pulp" (fig. 16, *e*).

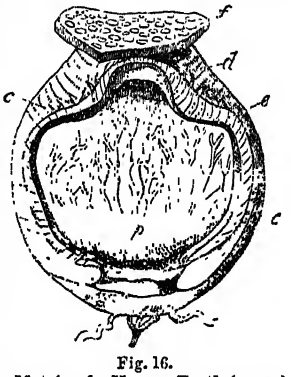

Fig. 16.
Matrix of a Human Tooth (magn.)

The linear cavity in the gums of the embryo, in which the pulps of the first series of teeth are formed, is termed the "primary dental groove:" where the first are succeeded by a second set of teeth, the pulps of these teeth are developed in a distinct recess, called the "secondary dental groove."

In man a certain proportion only of the teeth developed in the primary groove are displaced by teeth developed in a secondary groove; and the twenty teeth, so displaced, are called "milk-teeth," or deciduous teeth. The teeth of the molar series developed in the secondary groove are called "premolars," or bicuspids. The true molars are a continuation of the primary series, and are only "permanent," inasmuch as those of the secondary series are not co-extensive with them in number and position in the jaws. The differentiation of teeth, according to place and order of development, is illustrated (fig. 17) in the lower jaw of a young

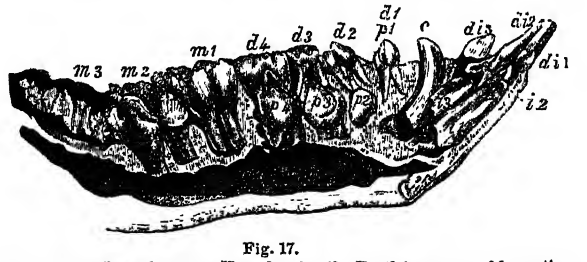

Fig. 17.
Section of Lower Jaw of a young Hog, showing the Teeth in course of formation.

hog. The teeth of the grinding series marked *d* 1 to *d* 4, *m* 1 to *m* 3, are successively developed from before backwards in the primary groove; the teeth marked *p* 2 to *p* 4 are developed in the secondary groove, as are also the successors of the canines and incisors. Both grooves

fonds, que dans quelque sens qu'on coupe la dent, on coupe plusieurs fois chacune des substances qui la composent; telles sont les dents molaires de *l'elephant*." The teeth of the 'Labyrinthodonts' would come under this definition more truly than those of the elephant, although they differ from them in having no enamel; for a molar of an elephant might be bisected vertically and transversely without cutting the tissues across more than once.

[1] Numerous other modifications of dental structure will be found described and figured in the author's *Odontography*, 4to, 1840–45.

[2] De Blainville, *Ostéographie*, passim.

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are converted into a closed chamber, and then subdivided into as many "formative cavities" as teeth, in the progress of dental development. The proper tissue of the dentinal pulp consists of nucleated cells (fig. 18, *p*), with capillary vessels and nerves invested by a structureless membrane, which disappears during the formation of the dentine. The superficial pulp-cells assume an elongated form as they approach the periphery; and after the formation of the tooth has commenced, their nuclei correspond in diameter and direction with the tubes of the contiguous cap of dentine. The cells are observed in a state of transition into dentine in the interspace between the pulp and the previously formed cap of dentine: they adhere to the latter when it is displaced from the pulp.

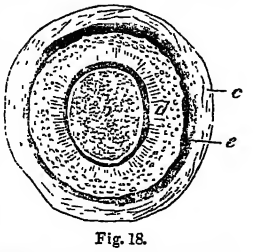

Fig. 18.
Section of the Matrix of the Pulp of a Human Tooth.

Observations on the pulp in its various stages of conversion into dentine, whilst in undisturbed connection with the calcified portion in the thin transparent lamelliform teeth of a fœtal shark (*Carcharias*), first yielded unequivocal demonstration of the organic continuity of the cap of dentine with the supporting vascular pulp; they also indicated some stages of the progress of the conversion of the pulp into dentine, and produced that clear idea of the nature and relations of dental development which is expressed (as previously quoted) in the *Theory of Dentification by Centripetal Calcification of the Pulp's Substance*, submitted to the French Academy in December 1839.[1] The following are the progressive steps of the calcifying processes, according to the writer's microscopic researches on the formation of the different substances which compose the more complex teeth of reptiles and mammals, as pursued in various species of both classes, but chiefly in the higher organized domestic animals:—

Three formative organs are developed, as already described, for the three principal or normal dental tissues. The dentinal pulp (figs. 16 and 18, *p* and *d*), or pulp proper, for the dentine; the "capsule" (figs. 16 and 18, *c*), for the cement; and the enamel-pulp (figs. 16 and 18, *e*), for the enamel. The essential fundamental structure of each formative organ is cellular; but the cells differ in each organ, and derive their specific character from the properties and metamorphoses of their nucleus, upon which the specific microscopical character of the resulting calcified substances depend. In the cells of the dentinal pulp the nucleus fills the parent cell with a progeny of nucleoli before the work of calcification begins; in the enamel-pulp the nucleus of the cell disappears, like the cytoblast of the embryo plant in the formation of most vegetable tissues; in the cells of the capsule the nucleus neither perishes nor propagates, but retains its individuality, and gives origin to the most characteristic feature of the cement,—viz., the radiated cell. The primordial material of each constituent of the tooth-matrix is derived from the blood, and special arrangements of the blood-vessels pre-exist to the development and growth of the constituent substances. A pencil of capillaries is directed to a particular spot in the primitive dentiparous groove, and terminates there by a looped net-work, from which spot a group of nucleated cells begin to arise in the form of a papilla. The cells of the papilla are, however, colourless, and the plexus of capillaries is confined to its base.

In the Mammalia (embryo calf of 3 inches in length) membranous septa are formed, into which the vessels extend, which septa cross the groove and inclose the papilla in a follicle; the epithelial gum closing in the follicle is shown at *f*, fig. 16. From the free margin of this follicle the processes are developed which indicate the configuration of the future crown of the tooth, and in the molars of the calf subsequently develop the re-entering folds on which the complex structure of the crown of the molar tooth depends. The primary dentinal papilla and its capsule rapidly increase by successive additions of nucleated cells, apparently derived by material supplied by the capillary plexus at the base; the capillaries now begin to penetrate the substance of the pulp itself, where they present a sub-parallel or slightly diverging penicillate arrangment, but preserve their looped and reticulate termination near the apex of the pulp. Fine branches of nerves accompany the capillaries, and terminate also in loops. The primary cells and the capillary vessels and nerves are imbedded in, and supported by, a homogeneous, minutely sub-angular mucilaginous substance, the "blastema." The cells which are smallest at the base of the pulp, and have large, simple, sub-angular nuclei, soon fall into linear series directed towards the periphery of the pulp; where the cells are in close proximity with that periphery, they become more closely aggregated, increase in size, and present the following changes in their interior:—A pellucid point appears in the centre of the nucleus, which increases in size, and becomes more opaque around that central point, rendering the compressorium requisite for its demonstration. A division of the nucleus in the course of its long axis is next observed, in the larger and more elongated cells, still nearer the periphery of the pulp, and to the field of calcification. The sub-divided and elongated nuclei become attached by their extremities to the corresponding nuclei of the cells in advance, and the attached extremities become confluent. Whilst these changes are proceeding, the calcareous salts of the surrounding plasma begin to be accumulated in the interior of the cells, and to be aggregated in a semitransparent state around the central granular part of the elongated nuclei, which now present the character of secondary cells (fig. 19, *d*), and the salts occupy, in a still clearer and more compact state, the interspaces *c* of such cells; the elongated granular matter of the terminally confluent secondary cells establishes the area of the tubes *d*, by resisting, as it would seem, the encroachments of the calcareous salts, the nuclear tracts receiving a smaller proportion of the salts in the condition of minute disgregated particles, which are usually arranged in a linear series of nodules, and contribute to cause the white colour of the moniliform area of the tube when viewed by reflected light, and its opacity when viewed by transmitted light. Thus the primitive existence of the granular nuclei, their multiplication in the primary or parent cell, their elongated form, their serial arrangement end to end, and terminal confluence, are indicated in the calcified pulp by the areæ of the dentinal tubes (fig. 19, *d*); the interspaces of the metamorphosed nuclei being occupied by calcareous salts in a clearer and more compact state *c*, with evidence, however, of a distinctness of nucleolar membrane or secondary cell from the cavity of the common containing cell, which sustains the

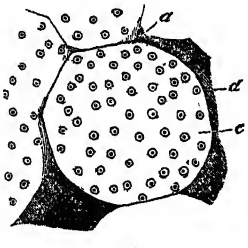

Fig. 19.
Highly-magnified portion of newly-calcified Dentinal Pulp (Calf).

[1] The general results of this communication were given in the *Comptes Rendus*, 1839, p. 783. The commission appointed by the French Academy to report on a subsequent memoir on the same subject, advert to some of the phenomena previously communicated by the present writer. "Quant aux préparations qui montrent l'aréolite de la pulpe, non seulement nous les avons reproduites avec succes; mais de plus nous avons constaté, à l'état frais, la granulation des areoles signalée par M. Richard Owen," *loc. cit.* 1842, p. 1063.

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interpretation of the "proper parietes" of the dentinal tube. The indications of the primitive boundary or proper parietes of the parent cell (fig. 19, *a*) are in like manner more or less distinctly retained, through a modification of the arrangement of the calcareous salts in the boundaries and in the interspaces of the cells. The salts are sometimes blended with the blastema in these interspaces in a disgregated condition, which renders them almost as opaque as the areæ of the tubes. When a layer of the calcified cells is carefully detached, the exposed uncalcified surface of the pulp presents the appearance of a net-work, the meshes being formed by the exposed cells and the intervening very thin layer of blastema. Each mesh, however, which gives a transparent or bright contour to the cell, when viewed by transmitted light, instead of presenting a single stellate nucleus, shows, by well-directed light under a higher power, several points, each of which have been torn from the cavities of the dentinal tubes in the displaced cap of dentine. A view of the thin transparent margin of the cap of a growing tooth, which may be cut off with a pair of fine scissors, easily affords the means of demonstrating the corresponding structure in that calcified part of the pulp. A slight change of focus is required to bring the ends of the tubuli in view, from that in which the clear outline of the dentinal cell is best seen. In proportion as the process of calcification approximates the cells, and as these have undergone the changes in their nucleolar contents preparatory to the proper arrangement of the hardening salts within, the proportion of the basal substance in the interspaces of the cells to the enlarged cells themselves decreases, and the cells become more readily detached, and seemingly independent, when torn out in the displacement of the cap of dentine. Although they are less adherent laterally to the basal substance of the pulp, they are more coherent with the cells of the same linear series, the tubes of the calcified cell accepting or effecting a union with the peripheral ends of the elongated granular nuclei, or nucleolar cavities of the contiguous cell in the next central layer. The angles at which the elongated nuclei, or successive portions of the dentinal tubuli, thus unite, constitute the secondary gyrations or curves of the cells. The primary curves depend upon the arrangement of the primary linear series of the parent cells or compartments of the pulp.

The original contour of these cells is most discernible after calcification of the teeth of the Mammalian class, and here with different degrees of distinctness in different species. They are the true dentinal cells or compartments (fig. 3, *a*, *a*), and must not be confounded with the so-called intertubular or interfibrous cells *f*, *g*, the first notice of which is due to Retzius. The diameter of the dentinal compartments or calcified primary cells of the pulp is usually one-fourth or one-half larger than that of the blood-disc of the species manifesting them. These cells are figured in the treatise on *Odontography* above referred to, in the *Mylodon* (pl. 79), in the incisive tusk of the *Dugong* (pl. 95), in the premolar (pl. 113), and in the canine (pl. 113, *a*) of the *Pteropus*, in the incisor of the chimpanzee (pl. 119, *a*), and of the human subject (pl. 123), and in the molar of a rhinoceros (pl. 139). They have been subsequently described and figured by Czermak.[1]

The altered mode of action, or change in the nuclei of the smaller central cells of the pulp, is the first and essential step in the modification of the dentinal tissue which produces the substances which are termed osteodentine and vasodentine. In the former, many of the cells retain their nucleus undivided, and the hardened salts are impacted around it in the interior of the cell, but enter only partially into the granular substance of the nucleus, in the minutely disgregated form, which produces the opacity and whiteness of the resulting corpuscle. In the formation of vasodentine many of the cells lose their nucleus, which seems to have become dissolved. In both the latter modifications of dental tissue the blood-vessels remain, and establish the wide tubular tracts in the calcified substance to which the name of the "vascular canals" is given. In true, hard, or unvascular dentine no trace of the blood-vessels remains; all has been converted into a much more minute calcified tubular tissue by the assimilative or intersusceptive properties of cells, and by the modification of their nucleolar contents. But the vascularity of the dentinal pulp, and especially the rich network of looped capillaries that adorns the formative peripheral layer at the period of its functional activity, have attracted general notice, and have been described by Hunter and subsequent authors on dental development. By most this phenomenon has been regarded as evidence of the secreting function of the surface of the pulp, and the dentine as an out-pouring from that vascular surface which was supposed to shrink or withdraw from the matter excreted. For it has been asked, "If the unvascular dentine be the effect of the conversion of the vascular pulp, by what process is all trace of the vascular ramifications obliterated, since none can be detected in such dentine?" The same question is equally applicable to the nerves of the pulp. In the explanation of this process attention must first be paid to the almost straight and sub-parallel course of the vessel in the pulp's substance, and to the remarkable regularity of form and size of the meshes of the terminal reticulation on the surface of the pulp.

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At the part where calcification has commenced the extremities of the capillaries are commonly found in a state of congestion, and crowded with blood-discs, which are pressed together into polyhedrons, and apparently stagnated and left out of the current of circulation. These aggregated blood-discs exhibited, in various and often in striking degrees, those changes of the contained matter to which their own multiplication may be due. In this present situation and condition it is obvious that such changes must be preparatory either to their disappearance and removal, or to some important share which they are destined to take in the development of the dental tissue. The stagnant corpuscles nearest the vascular and unchanged pulp exhibit the irregularity of contour which has given rise to the terms "mulberry" or "granulated," applied to such altered blood-discs when seen in other circumstances. These corpuscles in other respects, as colour, size, and general form, retained their usual character. The blood-discs nearer the cap of dentine exhibited more plainly the contained granules, to the commencing development of which the irregular contour above mentioned is due; this appearance was associated with an increase of size, a change from the circular to the elliptical form, and a gradual loss of the characteristic colour, which was longest retained by the central granular matter.

The enamel-pulp differs from the dentinal pulp at its first formation by the more fluid state of its blastema, and by the fewer and more minute cells which it contains. The part of the blastema next the dental pulp acquires more consistence by an increased number of its granules, and it contains more numerous and larger cells. Many of these show a nuclear spot, others a nucleus and nucleolus; the spherical nucleolar cells in the part of the blastema farther from the capsule are so numerous as to form an aggregate mass, with a small quantity of the condensed blastema in the minute interspaces left between the cells, which are pressed together into hexagonal or polygonal forms. In this state they constitute a great part of the enamel-pulp, which is of considerable extent in the complex molar teeth of the ruminants. The appearance produced by these

[1] *Beiträge zur Mikroskopischen Anatomie der Menschlichen Zähne*, 8vo, 1850, taf. i. und ii.

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aggregate cells, in a section of the tooth-matrix of a calf's molar, is compared by Raschkow[1] and Purkinjé to the actinenchyma of certain vegetable tissues, and the connecting condensed blastema to threads of cellular tissue. The field of the final metamorphosis of the cells into the moulds for the reception of the solidifying salts is confined to close contiguity with the surface of the dentinal pulp. Here the cells increase in length, lose all trace of their nucleus, and become converted into long and slender cylinders, usually pointed at both ends, and pressed by mutual contact into a prismatic form. These cylinders have the property of imbibing the calcareous salts of the enamel from the plasmatic fluid, and of compacting them in a clear and almost crystalline state in their interior—the disappearance of the nucleus being evidently the condition of the absence of any permanent cavity, cell, canal, or other modification of the mineral matter, at least in the enamel-fibres of the calf. In the human subject it is probable that the cavity of the cylinder may be subdivided, by a multiplication of delicate nucleoli, into compartments; or that the remains of such multiplied nucleoli may cause a modification of the walls of the cylinder, and so produce the characteristic transverse striæ of the enamel-fibre. This appearance is not presented in the enamel of the frog's tooth, nor in that of the teeth of the hog or calf, in which animals the writer's observations of the development of this tissue have been chiefly made. As the development proceeds, the cells in immediate contiguity with the calcified prisms undergo the same changes as their predecessors, and become united to them by their peripheral pointed extremities; whilst the fluid plasmatic contents of the cells are exchanged for the dense salts of which the enamel is chiefly composed. The selective surface formed by the organic membrane of the cell would seem to be destroyed by the very pressure resulting from its own action, and exerted by the contents of the closely-packed contiguous prisms when the cavities of the cells are completely filled. The membrane ceases, at least, to be distinguishable under the microscope from the solid contents of the cell, except at that surface of the enamel next the capsule, and which is still in progress of growth. What is remarkable here is, that not the whole of the actinenchymatous part of the enamel-pulp is converted into the long and slender prismatic cellular basis of the enamel; at least in the valleys of the complex crown of the molars of the ruminant and pachyderm (calf and colt). This part of the enamel-pulp originally occupies more space than the subsequent layer of enamel does; and this superfluous peripheral part seems to be absorbed, and its place to be occupied by a growth or thickening of the vascular capsule. No capillaries pass from the capsule into the actinenchymatous pulp of the enamel; nor has the writer been able to trace a blood-vessel into that part of the capsule which was actually the seat of the calcifying processes. Here, as in the dentinal and enamel pulps, the calcareous salts are selected and arranged by the assimilative, selective, and intus-susceptive properties of the cell walls, and by the repellent power of their nuclei. The enamel pulp bears a relation to the dentinal pulp analogous to that which the peripheral part of the matrix producing the vitrodentine of the shark's tooth bears to the body of the matrix forming the osteodentine. Evidence of the close connection between the enamel and dentine in the marsupial Mammals is given in plate 102 of the author's *Odontography*. The differentiation of the two tissues, and the distinction of their formative pulps, become greater in the higher Mammalia.

The blastema or fundamental tissue of the capsule is at first semitransparent, and of a pearly or opaline colour, but richly ornamented with blood-vessels. As the period of its calcification approaches, which is later than that of the dentinal pulp, it becomes denser, and exhibits numerous nucleated cells. The blastema itself presents more evidently a fine cellular or granular structure, in which the calcareous salts are impacted in a comparatively clear state, constituting the framework of the cemental tissue. The characteristic features of this tissue are due to the action of the proper nucleated cells upon the salts of the plasma diffused through the blastema, in which those cells are imbedded—the cells being characterized by a single large granular nucleus, which almost fills the clear area of the cell itself. If, when the formation of the cement has begun in the incisor or molar of a colt, one of the detached specks of that substance, with the surrounding and adhering part of the inner surface of the capsule in which it is imbedded, be examined, these nucleated cells are seen closely aggregated around the calcified part in concentric rows, the cells of which are farther apart as the rows recede from the field of calcification. Those next the cement rest in cup-shaped cavities in the periphery of the calcified part; just as the first calcified cells of the thick cement which covers the crown of a complex molar are lodged in the exterior of the enamel. These exterior cavities of the cement are formed by centrifugal extension of the calcifying process in the blastema in which the cells are imbedded. The calcareous salts penetrate, in a clearer and more compact state, the cavity of the cell; but their progress is arrested apparently by the nucleus, which maintains an irregular area, partly occupied by the salts in a subgranular, opaque condition, but chiefly concerned in the reception and transit of the plasmatic fluid, which enters and escapes by the minute tubes which are subsequently developed from the nucleolar cavity as calcification proceeds. The radiated cells or cavities thus formed are the most common characteristic of the cement, but not the constant one. The layer of the capsule which surrounds the crown of the human teeth, and of the simple teeth of *Quadrumana* and *Carnivora*, consists of the granular blastema, without or with very few nucleated cells; and the radiated corpuscles are consequently not developed, or are sparingly developed, in the cement which results from its calcification. In the thicker parts of the inflected folds of the capsule of the complex teeth of the *Herbivora*, traces of the vascularity of that part of the matrix are persistent, the blastema calcifying around certain of the capillaries, and forming the medullary canals. The parietes of these canals are traversed by minute tubes, continued from, or communicating with, the radiated cells.

In the deep sockets of the teeth of persistent growth the matrix is maintained by the constant additions of new blastema and cell material to the bases of the dentinal, enamel, and cemental pulps. The author has demonstrated the partial growth of the enamel-pulp along the side of the capsule corresponding to the convexity of the long incisor of the under-jaw of the porcupine, in the preparation now in the physiological series of the Hunterian collection (No. 375 A.)

Introduction.

Chemical analyses[2] of the composite substances, as built up by the organizing processes in the fundamental tissues of the matrix above described, have yielded the following results:—

Composition of teeth.

Incisors of Adult Man.

	Dentine.	Enamel.	Cement. I.	Cement. II.
Organic substance...	28·70	3·59	29·42	29 12
Inorganic substance.	71·30	96·41	70·58	70·88
	100·00	100·00	100·00	100·00

[1] *Meletemata circa dentium evolutionem*, 4to, 1835.

[2] These results are cited chiefly from Bibra's *Chemische Untersuchungen über die Knochen und Zähne*, 8vo, 1844.

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Molars of Adult Man.

	Dentine.	Enamel.
Phosphate of lime, with a trace of fluate of lime	66·72	89·82
Carbonate of lime	3·36	4·37
Phosphate of magnesia	1·08	1·34
Salts	0·83	0·88
Chondrine	27·61	3·39
Fat	0·40	0·20
	100·00	100·00

Berzelius' analysis gives—

	Dentine.	Enamel.
Phosphate of lime, with a trace of fluate of lime	64·3	88·5
Carbonate of lime	5·3	8·0
Phosphate of magnesia	1·0	1·5
Soda and muriate of soda	1·4	...
Cartilage and other animal matter	28·0	2·0
	100·0	100·0

Canine of a Lion.

	Dentine.	Enamel.
Phosphate of lime, with a trace of fluate of lime	60·03	83·33
Carbonate of lime	3·00	2·94
Phosphate of magnesia	4·21	3·70
Salts	0·77	0·64
Chondrine	31·57	9·39
Fat	0·42	a trace.
	100·00	100·00

Teeth of a Dolphin (Delphinus delphis).

	Dentine.	Cement.
Phosphate of lime, with a trace of fluate of lime	66·37	69·42
Carbonate of lime	1·84	1·79
Phosphate of magnesia	1·36	1·47
Salts	0·99	0·93
Chondrine	28·62	25·73
Fat	0·82	0·66
	100·00	100·00

Tusk of Elephant.

	Ivory.
Phosphate of lime, with a trace of fluate of lime	38·48
Carbonate of lime	5·63
Phosphate of magnesia	12·01
Salts	0·70
Chondrine	42·94
Fat	0·24
	100·00

Tusk of Wild Boar.

	Dentine.
Phosphate of lime, with a trace of fluate of lime	60·00
Carbonate of lime	2·51
Phosphate of magnesia	6·43
Salts	0·43
Chondrine	30·50
Fat	0·13
	100·00

Incisors of Ox.

	Dentine.	Enamel.	Cement.
Phosphate of lime, with a trace of fluate of lime	59·57	81·86	58·73
Carbonate of lime	7·00	9·33	7·22
Phosphate of magnesia	0·99	1·20	0·99
Salts	0·91	0·93	0·82
Chondrine	30·71	6·66	31·31
Fat	0·82	0·02	0·93
	100·00	100·00	100·00

Crocodile.

	Dentine.	Cement.
Phosphate of lime, with a trace of fluate of lime	53·69	53·39
Carbonate of lime	6·30	6·29
Phosphate of magnesia	10·22	9·99
Salts	1·34	1·42
Chondrine	27·66	28·15
Fat	0·79	0·76
	100·00	100·00

Pike (Esox lucius), *Large Teeth of Lower Jaw.*

	Dentine.
Phosphate of lime, with a trace of fluate of lime	63·98
Carbonate of lime	2·54
Phosphate of magnesia	0·73
Salts	0·97
Chondrine	30·60
Fat	1·18
	100·00

The proportion of mineral or inorganic substance would seem to vary, within certain limits, in different individuals of the same species. Thus, in the molar teeth of one man Bibra found 79·00 of inorganic matter, and in another, 71·99; whilst Berzelius found 72·0. The proportion of inorganic matter in hard dentine will depend in some degree upon the number of dentinal tubes, from the area of which the salts are in part excluded: thus, in the modified dentine (ivory) of the elephant's tusk, in which the tubuli are more numerous, close-set, and extensively undulated in a given space than in ordinary dentine, the organic bears a greater proportion to the inorganic matter than in the dentine of the teeth of most other Mammals. The cement of the composite molar teeth of the ruminants and of the elephant contains a little more organic matter than the dentine does; but in the cetaceous dolphin it contains a rather less proportion, and is consequently harder.

Nerves of the teeth.

The nerves of the teeth are derived from the trigeminal or fifth pair, of which the second division supplies those of the upper jaw, the third division those of the lower jaw (fig. 20). In the human subject, the three dental branches

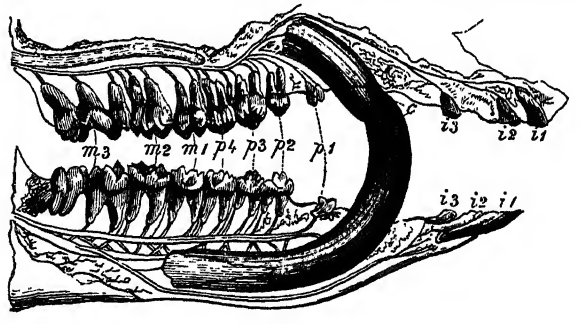

Fig. 20.
Upper and Lower Jaws of a Hog, dissected to show the Nerves of the Teeth.

of the infra-orbital nerve intercommunicate by their primary branches, from which, and from a rich plexus formed by secondary branches upon the membrane lining the antrum, two sets of nerves are sent off to the alveolar processes of the upper jaw: one set (*rami dentales*) supplies the teeth, the other (*rami gingivales*) the osseous tissue of the jaw and the gums. The latter agree in number with the intervals of the teeth, as the proper dental nerves do with the teeth themselves. These two sets are not, however, so distinct but that some intercommunications are established between the fine branches sent off in their progress to the parts they are specially destined to supply. The *rami dentales* take the more direct course through the middle part of the osseous tissue to the teeth, penetrate the orifices of the fangs, and form a rich plexus with rhomboidal meshes

Introduction.

upon the coronal surface of the pulp, the peripheral elementary filaments returning into the plexus by loops.

In the lower jaw, the dental nerve, besides supplying the proper nerves to the teeth, also forms a rich plexus, in which it is joined by some branches from the division of the nerve that afterwards escapes by the *foramen mentale*, and from this plexus the cancellous tissue of the bone, as well as the gums, are supplied.

In the dog and other Carnivora the nerve of the laniary tooth is conspicuous from its size: that which supplies the still more developed analogous tooth or tusk of the boar (fig. 20, *c*) is still more developed, having relation also to the continual reproduction of the matrix at the base of the tusk. In the lower jaw of the porcupine (fig. 21) the nerve of the great incisor is given off from the dental nerve (*n*),

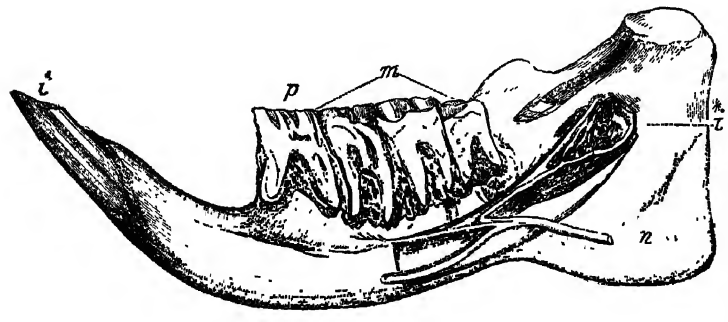

Fig. 21.

Lower Jaw of a Porcupine, dissected to show the Nerves of the Great Incisor, natural size.

near the middle of its course through the osseous canal, and returns at an acute angle to penetrate the cavity at the base of the scalpriform tooth, and supply its persistent pulp *i*. This recurrent course indicates the progressive change in the relative position of the pulp to the origin of its nerve.

Besides the branches for the molar teeth, many smaller filaments penetrate the spongy texture of the bone, and form a rich plexus, from which the gum derives its filaments. The maxillary plexus is most richly developed, in the horse, above and between the alveoli of the three premolar teeth; it is less complex where it supplies the molar teeth, their alveoli, and the gums. In the lower jaw of the horse a very rich plexus begins to be formed in the cancellous substance of the bone by branches of the dental nerve soon after its entry into the canal. The intercommunications between the dental and gingival nerves, and those supplied to the osseous tissue from the supra-maxillary and infra-maxillary plexuses, explain the sympathies manifested in neuralgy and rheumatic pains between the teeth and the osseous cavities in which they are implanted.

Histology of teeth.

The class of tissues in which teeth should rank has frequently been a subject of controversy in systems of histology; the fact being overlooked, that they have not the same unity of composition as bones or epidermal appendages. One constituent of teeth, viz., the cement, ought clearly to rank with the osseous tissue; and the dentine or ivory, which was described for the last time, probably, in July 1838, as being, "like the hair, arranged in concentric layers,"[1] bears, on the contrary, a close analogy to bone in structure, and is almost identical with it in chemical composition. Its modifications, called "vasodentine" and "osteodentine," form intermediate gradations between the hard dentine and true bone. True enamel is a tissue *per se;* but in the teeth of fishes there are several intermediate stages of gradation, which link enamel to dentine, as the dentine itself in most fishes passes gradually into bone. Heusinger[2] admits that the relation of the teeth to the corneous tissue (*horngewebes*) is not clearly elucidated in human anatomy, but he affirms that it is most conclusively established in that of the lower classes of animals.

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No doubt, in tracing the modifications of the dental system through the animal kingdom, we find true horny productions substituted for teeth in certain vertebrate species, as the Ornithorhynchus, whale, tortoise, &c. So likewise the office of teeth is performed by parts (modified as to form) of the crustaceous and chitinous integuments of the articulate classes; but there are no transitional or intermediate structures, such as Heusinger alludes to, between teeth and nails, horns or hair. The lamellar disposition traceable in the texture of the hardest dentine is much more closely similar to that of bone, especially the concentric plates surrounding the Haversian canals, than to the texture of nails. The structure of the tooth of Orycteropus is essentially like that of all true teeth: the apparent resemblance which it presents to the horn of the rhinoceros, or to baleen, arises from its being compounded of many minute parallel and elongated denticles. And the close resemblance in intimate structure and chemical composition between true teeth and bones being established, it may be observed that the osseous tissue is not confined to the endo-skeleton: it is developed largely to form the exo-skeleton in fishes, in the loricate reptiles, and even in the Mammalian class, —as, for example, in the armadillos, where bone is substituted, to strengthen the integument, for horn, which forms the scaled armour of the allied pangolins. Now, the relation of the tooth of the armadillo to that of the Ornithorhynchus is precisely analogous to that which subsists between the osseous plates of the armadillo, and the corneous scales of the Manis; but this relation no more establishes identity of tissue or system of tissues in the one case than in the other.

The general form of the matrix or formative organ of teeth, and the relative position of the dentinal pulp to its product, bear a close analogy with those of the formative organ of hairs, bristles, shells, and other productions of the epidermal system. In these, however, the papilla or pulp is developed from the external skin; in the teeth from the mucous membrane or internal skin. Teeth further agree with the extra-vascular appendages of the skin in being shed and reproduced,—sometimes once,—sometimes frequently during the lifetime of the individual; the latter condition may be termed "interrupted reproduction." In some cases, again, as with certain epidermal productions, the reproduction of the tooth is "uninterrupted," and goes on continuously during the lifetime of the individuals, new matter being added to the base as the old is worn away from the apex or working surface of the tooth.

A tooth, when fully formed, is subject to decay, but has no inherent power of reparation. A tooth of limited growth can only increase in size after its formation is completed by abnormal growth of its most highly organized constituent, the cement. Thus the analogy of the dental organs to those of the corneous system holds only in their mode of development,[3] in their shedding and reproduction, and in their exposure to external influences, and to the contact of extraneous bodies: but the antlers of deer are similarly exposed, and are likewise shed and reproduced annually, and also contemporaneously with the fall and reproduction of the hair; yet antlers are not therefore classed with the horny tissues, any more than the bony cone of the horns of the cavicorn ruminants.

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[1] *Medico-Chirurgical Review*, p. 43.

[2] *System der Histologie*, 4to, 1823, p. 160.

[3] The cells and fibres of the horny tissues are formed in, and not excreted from, the surface of their formative pulps.

Teeth of Fishes.

Sect. I.—TEETH OF FISHES.

The fishes of Great Britain, and those which are known to us by vernacular names, form a comparatively small part of the class; but wherever the dentition of such is described, the species will be indicated in the present article by their common names. As, however, many interesting modifications of the dental organs occur in exotic fishes, known by no other names than those by which they are recorded in the systems and catalogues of naturalists, the information respecting their dentition which is here endeavoured to be given must be unavoidably confined to those who combine some knowledge of Zoology with that of Comparative Anatomy.

Excellent illustrations of the dental system in fishes are given in the article Ichthyology, as, *e.g.*, from the predaceous *Alepisaurus* (p. 213, fig. 19), the phytiphagous *Plotosus* (p. 220, fig. 50), and in various other species, from figs. 52 to 62 inclusive, accompanied with so exact a summary of the general modifications of the system in the piscine class, as leaves little to be added in the present article on that head. Yet this little appears necessary; for the teeth of fishes, whether we study them in regard to their number, form, substance, structure, situation, or mode of attachment, offer a greater and more striking series of varieties than do those of any other class of animals.

Number. As to *number*, they range from zero to countless quantities. The lancelet, the ammocete, the sturgeon, the paddle-fish, and the whole order of *Lophobranchii*, are edentulous. The Myxinoids have a single pointed tooth on the roof of the mouth, and two serrated dental plates on the tongue. The tench has a single grinding tooth on the occiput, opposed to two dentiferous pharyngeal jaws below. In the lepidosiren (fig. 36), a single maxillary dental plate is opposed to a single mandibular one, and there are two small denticles on the nasal bone. In the extinct sharks with crushing teeth, called *Ceratodus* and *Ctenodus*, the jaws were armed with four teeth, two above and two below. In the *Chimeræ* two mandibular teeth are opposed to four maxillary teeth. From this low point the number in different fishes is progressively multiplied, until in the pike and many other fishes the mouth becomes crowded with countless teeth.

Substance. With reference to the main and fundamental tissue of tooth, we find not fewer than six leading modifications in fishes:—Hard or true dentine,—*Sparoids, Labroids* (fig. 6), *Lophius, Balistes, Pycnodonts, Prionodon, Sphyræna, Megalichthys, Rhizodus, Diodon, Scarus:* Osteo-dentine,—*Cestracion, Acrodus, Lepidosiren, Ctenodus, Hybodus, Percoids, Sciænoids, Cottoids, Gobioids*, and many others: Vaso-dentine,—*Lamna* (fig. 7), *Psammodus, Chimæroids, Pristis, Myliobates:* Plici-dentine,—*Lophius, Holoptychius, Lepidosteus oxyurus*, at the base of the teeth: Labyrintho-dentine,—*Lepidosteus platyrhinus, Bothriolepis:* and Dendro-dentine,—*Dendrodus* (fig. 14); besides the compound teeth of the *Scarus* and *Diodon*.

Structure. One structural modification may prevail in some teeth, another in other teeth of the same fish; and two or more modifications may be present in the same tooth, arising from changes in the process of calcification and a persistency of portions or processes of the primitive vascular pulp or matrix of the dentine. The modifications of dentine, called vasodentine and osteodentine,[1] predominate much more than in the higher Vertebrata; and they thus more closely resemble the bones which support them. There is, however, great diversity in respect of substance. The teeth of most of the Chætodonts are flexible, elastic, and composed of a yellowish subtransparent albuminous tissue; such, likewise, are the labial teeth of the Helostome, the premaxillary and mandibular teeth of the Goniodonts, and of that percoid genus thence called *Trichodon*. In the Cyclostomes (lampreys) the teeth consist of a denser albuminous substance. The upper pharyngeal molar of the carp consists of a peculiar brown and semitransparent tissue, hardened by salts of lime and magnesia. The teeth of the flying-fish (*Exocœtus*) and sucking-fish (*Remora*) consist of osteodentine. In many fishes, *e.g.*, the *Acanthurus, Sphyræna*, and certain sharks (*Lamna*, fig. 7), a base, or body of vasodentine, is coated by a layer of true dentine, but of unusual hardness, like enamel; in *Prionodon* this hard tissue predominates. In the *Labrus* the pharyngeal crushing teeth consist wholly of hard or unvascular dentine (fig. 6). In Pycnodonts, and many other fishes, the body of the tooth consists of ordinary unvascular dentine, covered by a modification of that tissue which I have called "vitrodentine," from its clear, polished, enamel-like character; but this is not enamel, nor the product of a distinct organ from the dentinal pulp: it differs from ordinary dentine in the greater proportion of the mineral particles, their more minute diffusion through the gelatinous basis, and in the straighter course and more minute size of the dentinal tubes; it results from the calcification of the external layer of the dentinal pulp, and is the first part of the tooth which is formed. In *Sargus* and *Balistes* the body of the tooth consists of true dentine, and the crown is covered by a thick layer of a denser tissue, developed by a distinct organ, and differing from the "enamel" of higher animals only in the more complicated and organized mode of deposition of the earthy salts. The ossification of the capsule of the complex matrix of these teeth covers the enamel with a thin coating of "cement." In the pharyngeal teeth of the *Scarus* a fourth substance is added by the ossification of the base of the pulp after its summit and periphery have been converted into hard dentine; and the teeth thus composed of cement, enamel, dentine, and osteodentine, are the most complex, in regard to their substance, that have yet been discovered in the animal kingdom.

The tubes which convey the capillary vessels through the substance of the osteodentine and vasodentine of the teeth of fishes[2] were early recognised on account of their comparatively large size,—as by André, *e.g.*, in the teeth of *Acanthurus*, and by Cuvier and Von Born in the teeth of the wolf-fish and other species. Leeuwenhoek had also detected the much finer tubes of the peripheral dentine of the teeth of the haddock. These dentinal tubuli are given off from the parietes of the vascular canals, and bend, divide, and subdivide rapidly in the hard basis-tissue of the interspaces of those canals in osteodentine; the dentinal tubuli alone are found in true dentine, and they have a straighter and more parallel course, usually at right angles to the outer surface of the dentine. Those conical teeth of fishes which, when fully-formed, consist wholly or in great part of osteodentine or vasodentine, always first appear with an apex of hard or true dentine. In some fishes the simple central basal pulp-cavity of such teeth, instead of breaking up into irregular or parallel canals, sends out a series of vertical plates from its periphery, which, when calcified, give a fluted character to the base of the tooth, *e.g.*, in *Lepidosteus oxyurus*. Sometimes such radiating vertical basal plates of dentine are wavy in their course, and send off narrow processes from their sides; and as a thin layer of the outer capsule inter-

[1] *Odontography*, Introduction, p. lxxii.

[2] The vasodentine of *Pristis* and *Myliobates* is like that of the teeth of the Cape ant-eater (*Orycteropus*); the vasodentine of the Psammodonts resembles that which forms the base of the tooth of the sloth and megatherium; the vasodentine of Mammals differs from the osteodentine, in the absence of the radiated "Purkingian" cells.

Teeth of Fishes.

digitates with the outstanding plates of the dentinal pulp, and becomes co-calcified with them, a transverse section of such a tooth presents a series of interblended wavy or labyrinthic tracts of thick dentine radiating from the centre, and of thin cement converging towards the centre of the tooth.

An analogous but more complicated structure obtains, when the radiating wavy vertical plates of dentine dichotomize, and give off from their sides, throughout their course, numerous branch plates and processes, which are traversed by medullary sinuses and canals, with their peripheral terminations dilated, and becoming the centres of lobes or columns of hard dentine. The transverse section of such teeth gives the appearance of branches of a tree, with leaf-stalks and leaves radiating from the central pulp-cavity to the circumference of the tooth; whence the fossil fish in which this structure was first detected has been called *Dendrodus* (fig. 14).

Situation.

With respect to *situation* the teeth in sharks and rays are limited to the bones (maxillary and mandibular) which form the anterior aperture of the mouth. In the carp and other Cyprinoids the teeth are confined to the bones (pharyngeal and basi-occipital) which circumscribe the posterior aperture of the mouth. The wrasses (*Labrus*) and the parrot-fishes (*Scarus*) have teeth on the premaxillary and premandibular bones, as well as on the upper and lower pharyngeals; both the anterior and posterior apertures of the mouth being thus provided with instruments for seizing, dividing, or comminuting the food, the grinders being situated at the pharynx. In most fishes teeth are developed also in the intermediate parts of the oral cavity; as on the palatines, the vomer, the hyoid bones, the branchial arches; and, though less commonly, on the pterygoids, entopterygoids, the sphenoids, and even on the nasal bone (fig. 36, *c*). It is very rare to find teeth developed on the true superior maxillary bones; but the herring and salmon tribes, some of the ganoid fishes, and the great *Sudis*, are examples of this approach to the higher Vertebrates. Among the anomalous positions of teeth may be cited, besides the occipital alveolus of the carp,[1] the marginal alveoli of the prolonged, depressed, well-ossified rostrum of the saw-fish (*Pristis*). In the lampreys, and in *Helostomus* (an osseous fish), most of the teeth are attached to the lips. Lastly, it is peculiar to the class *Pisces*, amongst Vertebrata, to offer examples of teeth developed in the median line of the mouth, as in the palate of the Myxines; or crossing the symphysis of the jaw, as in *Notidanus*, *Scymnus*, and *Myliobates*.

Attachment.

Nor is the mode less varied than the place of *attachment*. The teeth of *Lophius*, *Pœcilia*, and *Anableps* are always moveable; in most fishes they are anchylosed to the jaw by continuous ossification from the base of the dental pulp, the histological transition being more or less gradual from the structure of the tooth to that of the bone. Sometimes we find, not the base, but one side of the tooth anchylosed to the alveolar border of the jaw, and the teeth oppose each other by their sides instead of their summits (*Scarus*); in *Pimelodus*, however, where the teeth are thus attached, the crown is bent down in the upper teeth, and is bent up in the lower ones, at right angles to the fang, so that they oppose each other in the normal way. Certain teeth of recent or fossil cartilaginous fishes have their base divided into processes like fangs; but these serve for the attachment of ligaments, and are not set in bony sockets like the true fangs or roots of the teeth of Mammals. Some sharks have two divaricating fangs. Some fossil teeth, referred to the genus *Petalodus* by Agassiz, with the specific name "radicans," have the base divided into several fangs or processes, indicating a generic distinction. The base of anchylosed teeth is at first attached to the jaw-bone by ligament; and in the cod-fish, wolf-fish, and some other species, as calcification of the tooth progresses towards its base, the subjacent portion of the jaw-bone receives a stimulus, and develops a process corresponding in size and form with the base of the tooth. For some time a thin layer of ligamentous substance intervenes, but anchylosis usually takes place to a greater or less extent before the tooth is shed. Most of the teeth of the Lophius retain the primitive ligamentous connection. The ligaments of the large internal or posterior teeth of the upper and lower jaws radiate on the corresponding sides of the bones, the base of the tooth resting on a conformable alveolar process.

Teeth of Fishes.

Some implanted teeth in the present class have their hollow base further supported, like the claws of the feline tribe, upon a bony process arising from the base of the socket; the incisors of the file-fish (*Balistes*, fig. 22), *e.g.*, afford an example of this double or reciprocal gomphosis. In fig. 22 the teeth in place, and the outer wall of the premaxillary, have been removed to show, as at *a*, the socket and the basal peg of the fully developed incisor; at *b* the apex of a successional incisor, which has worn away the peg, and caused the fall of the incisor it was about to succeed; and at *c* the less advanced germ of the tooth destined to succeed that which was supported by the peg *a*.

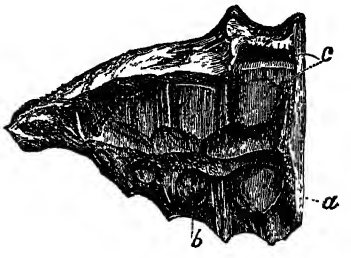

Fig. 22.
File-Fish (*Balistes forcipatus*).

The vertical section of a pharyngeal jaw and teeth of the wrasse (*Labrus*, figs. 23 and 6), would afford the architect a model of a dome of unusual strength, and so supported as to

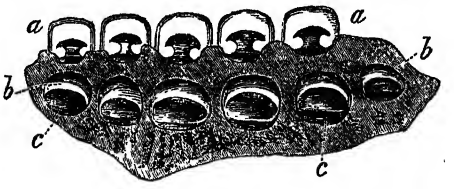

Fig. 23.
Section of Pharyngeal Bone and Teeth of a Wrasse (*Labrus*.)

relieve from pressure the floor of a vaulted chamber (fig. 23, *c*, *c*) beneath. The base of the dome-shaped tooth *a* is slightly contracted, and is implanted in a shallow circular cavity, the rounded margin of which is adapted to a circular groove in the contracted part of the base; the margin of the tooth, which immediately transmits the pressure of the bone, is strengthened by an inwardly projecting convex ridge. The masonry of this inner buttress, and of the dome itself, is composed of hollow columns, every one of which is placed so as best to resist or transmit in the due direction the external pressure (fig. 23). The floor of the alveolus is thus relieved from the office of sustaining the tooth: it forms, in fact, the roof of a lower vault, in which the germ of a successional tooth (fig. 23, *b*, *b*) is in course of development. Had the crushing tooth in use rested, as in the wolf-fish, by the whole of its base upon the alveolus, the supporting plate, gradually undermined by the growth of the new tooth, must have given way, and been forced upon the subjacent delicate and highly vascular and sensitive matrix of the half-formed tooth. But the superincumbent pressure is exclusively sustained by the border of the alveolus, whence it is transferred to the walls dividing the vaulted cavities containing the germs of the new teeth.

[1] *Odontography*, pl. 8, vol. iii., p. 980, fig. 518.

Teeth of Fishes.

The roofs of these cavities yield to the absorbent process consequent on the growth of the new teeth, without materially weakening the attachment of the old teeth, and without the new teeth being subjected to any pressure until their growth is sufficiently advanced to enable them to bear it with safety. By this time the sustaining borders of the old alveolus are undermined, and the worn-down tooth is shed.

Many analogous structures could be adduced did space permit: in fact, the whole of this part of the organization of fishes is replete with beautiful instances of design, and instructive illustrations of animal mechanics.

Development.

As might have been anticipated from the discovery of the varied and predominating vascular organization in the teeth of fishes, and the passage from non-vascular dentine to vascular dentine in the same tooth, the true law of the development of dentine "by centripetal metamorphosis and calcification of the cells of the pulp," was first definitely enunciated and illustrated from observations made on the development of the teeth of fishes.[1]

It is interesting to observe in this class the process arrested at each of the well-marked stages through which the development of a mammalian tooth passes. In all fishes the first step is the simple production of a soft vascular papilla from the free surface of the buccal membrane. In sharks (fig. 24) and rays, these papillæ *c* do not proceed to sink into the substance of the gum, but are covered by caps of an opposite free fold of the buccal membrane. These caps *f*, *g*, do not contract any organic connection with the papilliform matrix; but, as this is converted into dental tissue, the tooth is gradually withdrawn from the extraneous protecting cap to take its place and assume the erect position on the margin of the jaw, as at *a*, *b*. Here, therefore, is represented the first and transitory "papillary" stage of dental development in Mammals; and the simple crescentic cartilaginous maxillary plate, with the open groove behind containing the germinal papillæ of the teeth, offers in the shark a magnified representation of the earliest condition of the jaws and teeth in the human embryo.

In many fishes, *e.g.*, the angler (*Lophius*) and pike, the dental papillæ become buried in the membrane from which they rise, and the surface to which their basis is attached becomes the bottom of a closed sac; but this sac does not become inclosed in the substance of the jaw; so that teeth at different stages of growth are brought away with the thick and soft gum, when it is stripped from the jaw-bone. The final fixation of teeth so formed is effected by the development of ligamentous fibres in the sub-mucous tissue between the jaw and the base of the tooth; which fibres become the medium of connection between those parts, either as elastic ligaments, or by continuous ossification. Here, therefore, is represented the "follicular" stage of the development of a mammalian tooth; but the "eruptive" stage takes place without previous inclosure of the follicle and matrix in the substance of the jaw-bone.

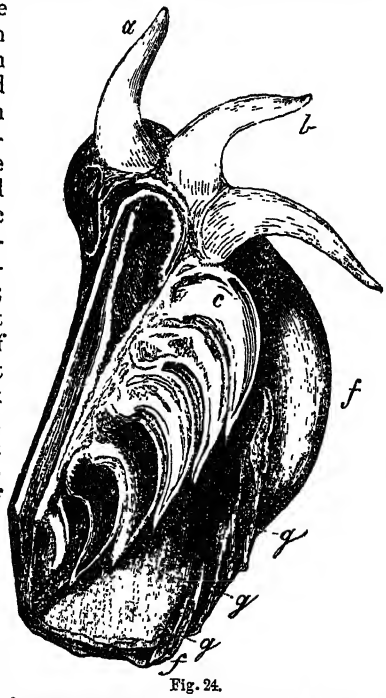

Fig. 24. Section of the Jaw and Teeth of a Shark (*Lamna*).

Teeth of Fishes.

In *Balistes* (fig. 22), *Scarus* (fig. 34), *Sphyræna*, the Sparoids, and many other fishes, the formation of the teeth presents all the usual stages which have been observed to succeed each other in the dentition of the higher Vertebrata: the papilla sinks into a follicle, becomes surrounded by a capsule, and is then included within a closed alveolus of the growing jaw (fig. 22, *c*), where the development of the tooth takes place, and is followed by the usual eruptive stages. A distinct enamel-pulp is developed in *Balistes*, *Scarus*, *Sargus*, and *Chrysophrys*.

Squalidæ, or sharks.

No cartilaginous fish has teeth implanted in maxillary alveolar cavities, or confluent with the substance of the jaw; they are attached to the fibrous and mucous membrane which cover the maxillary cartilages; thence it occurs, in certain genera, as *Myliobates* and *Scymnus*, that a single tooth in the median plane may lie directly across the symphysis, and be supported by the two rami of the jaw. The Plagiostomes, like many other natural families of fishes, present such modifications of their common and characteristic type of structure as fit them for very different habits of life, and the acquisition of different kinds of food. The active and predatory sharks are associated in this order with the sluggish omnivorous rays, and the dental system presents every grade of modification from the laniary to the molary type. The *Lamna* (fig. 24), with its teeth exclusively adapted for holding, piercing, and lacerating, and the *Myliobates* (fig. 26), with its maxillary mosaic pavement of flattened molars, form the two extremes of the series.

The sharks, or *squaloid* Plagiostomes, with few exceptions, have teeth of a conical, sharp-pointed, more or less compressed form, sometimes with trenchant or serrate edges and accessary basal denticles; they are arranged along the margin and posterior surface of the jaws in close-set vertical rows of from three to thirteen teeth in each row, according to the species. The teeth of the contiguous rows in certain genera, as *Selache* and *Lamna*, are parallel to each other; but in *Galeus* and *Carcharias* they are placed alternately, so that the base of one tooth advances laterally into the interspace of two teeth of the contiguous row, and reciprocally; but the laterally contiguous teeth are never articulated with each other, as in certain rays.

In general the anterior or external tooth only of each row is erect, the rest being recumbent. In *Lamna*, however, the second and third teeth are commonly seen in positions intermediate between those of the erect anterior (fig. 24, *a*) and the recumbent posterior teeth (*c*). It is scarcely necessary to repeat, that although the teeth of the sharks possess greater individual mobility than those of the rays, the recumbent ones (fig. 24, *c*) cannot, as has been supposed, be voluntarily erected. These teeth are still in progress of development, and several of them are covered by a reflection of the mucous membrane of the mouth (fig. 24, *g*), which would be lacerated by such a movement; it is by a gradual change of position in the fibrous membrane, to which their base is attached, that the altered direction of the consolidated teeth is effected.

The formation of the teeth of the sharks, as of many other fishes, exemplifies, on a large scale, the earliest or papillary stage of dental development in the higher classes of animals. It is not succeeded here by either a follicular or an eruptive stage; the formative papillæ are never inclosed, and consequently never break forth. The pulp, when consolidated by the deposition of the calcareous salts in the pre-existing cells and tubes, is gradually withdrawn from the protective sheath (fig. 24, *g*), which the thecal fold of mucous membrane *f*, *f* afforded during the early stages of its formation. In the uterine fœtus, one foot long, of the great white shark (*Charcharodon*), the jaws seem at first sight to be edentulous; a fissure presents itself on the inner side of the margin of each jaw, running parallel with it, between the thin smooth membrane covering the convex edge of the cartilage, and the free margin of a fold of mucous membrane which lies parallel to and upon the inner side of the jaw. When this fold is drawn away from the jaw, the minute teeth are exposed, arranged in the usual vertical rows; these points are all directed backwards and towards the base of the jaw, and are seen to slip out of fossæ or sheaths in the membranous folds, as this is gradually reflected backwards and

[1] In the author's *Hunterian Lectures*, delivered at the Royal College of Surgeons, May 1839. See also *Compte Rendu de l'Académie des Sciences*, Dec. 1839, p. 784; and *Odontography*, Introduction, and part i., *passim*.

Teeth of Fishes.

towards the base of the jaw. Here the anterior lamina of the fold, which, from its office, may be termed "thecal," is continuous with the mucous membrane at the base of the rows of teeth; the posterior layer is reflected backwards to the front line of attachment of the tongue. Close to the anterior line of reflection there is a row of simple conical papillæ; in the succeeding row the papillæ are larger, the cone broader and flatter, and its apex is covered with a small cap of dense and glistening dental substance, which is readily removed, though not without displacement of part of the dental pulp, the granules of which, adherent to the cavity of the displaced dental cap, are always readily recognisable under the microscope. The third series of papillæ, counting from below in the lower jaw, have acquired the size and shape of the future tooth, with the crenate edges well marked; half the tooth is completed, and its removal from the fleshy base of the pulp cannot be effected without evident laceration of the pulp. When this is done under the microscope, the torn processes of the pulp continued into the medullary canals of the new-formed tooth are plainly visible. The fourth tooth is completely formed, as also the fifth and sixth in the ascending series: these progressively diminish in size. The last or highest, which is first exposed on reflecting the thecal fold, and the first which was completed in the order of development, consists of a simple cone, similar in form and size to the apical third of the ordinary-sized teeth below it; yet its growth is quite completed, and its base firmly attached to the maxillary membrane.

In a fœtus of a white shark (*Carcharias ferox*) 3 inches long, which had not lost its external branchiæ, the membranous groove between the jaw and thecal fold was much shallower, and only two rows of papillæ were present on the maxillary membrane. The minute anterior teeth in the more advanced fœtus were developed from these primitive papillæ, which must be succeeded by others of progressively larger size, till the normal form and dimensions of the adult teeth are attained. The fœtal shark is peculiarly favourable for such comparisons, as it presents numerous pulps and teeth in every stage of formation, easily detached, and without violence, from their exposed situation, and of a flattened form, well adapted for microscopical observation.

The unossified pulps, examined with a high power, consist of semi-opaque polyhedral granules or cells suspended in a clear *matrix*, and the whole is inclosed in a tough transparent membrane, which forms the outer surface of the pulp. Beneath this membrane, at the crenate margins, the nucleated cells are arranged in lines precisely corresponding with those of the subsequent dentinal tubes. The formation of the tooth commences by the deposition of earthy particles in the tough external membrane of the pulp. The present writer has been unable to recognise the distinct arrangement of the hardening salts in this layer. It is transparent, extremely dense, and forms the enamel-like polished coating of the tooth; in sections of fully-formed teeth, the finest terminal branches of the parallel peripheral dentinal tubes are lost in the above clear enamel-like substance. When this outer layer of the apex of the tooth is completed, it is so easily detached from the subjacent pulp, that it might be readily supposed that there was no organic connection between them. If, however, the so exposed pulp be now examined with the microscope, and compared with an uncalcified pulp, it is seen to be no longer covered with the smooth, dense membrane observable in the latter; but the apical edges, from which the enamel-like cap has been detached, appear villous or floccular. It is obvious that the first shell of the tooth has been neither transuded from the superficies of the external membrane of the pulp, nor has been deposited between that membrane and the granular part of the pulp, but is due to the conversion of the external membrane into a dense enamel-like bone. The formation of the body of the tooth by deposition of earthy particles in pre-existing and pre-arranged cavities is still more satisfactorily demonstrable. In proportion as the formation of the tooth has advanced, the difficulty of separating the calcified from the uncalcified portion of the pulp is increased; and at the same time it becomes easier to detect the continuation of the processes of the pulp into those medullary canals which form so many separate centres of radiation of the plexiform dentinal tubes.

As a consequence of a formation of a tooth by conversion of, instead of transudation from, a pre-existing pulp, the successive formation of these pulps necessarily follows where a succession of teeth is required. These reproductive pulps are developed, in the shark, from the vascular mucous membrane at the angle of reflection of the thecal fold upon the groove of the basal line of the jaws. They gradually advance from this situation towards the margin of the jaw, the centripetal calcification extends as they advance, and consolidation is completed (as in fig. 24, *c*) by the time the teeth are ready to change their recumbent for the erect position *ba*, and take the place of the tooth previously shed.

Teeth of Fishes.

Raiidæ, or Rays.

The teeth of the rays are in general more numerous than those of the sharks; they have less mobility, are more closely impacted, and in some cases are laterally united together by fine sutures, so as to form a kind of mosaic pavement on both the upper and lower jaws. The *Myliobates*, or eagle-rays, which present the last-mentioned condition, unique in the vertebrate sub-kingdom, have large and massive teeth (fig. 26); but in the rest of the present family of cartilaginous fishes, the teeth (fig. 25) are remarkable for their small size as compared with those of the sharks. The teeth in some species of rays are adapted for crushing, but in others they have the middle or one of the angles of the crown produced into a sharp point. In all genera of the ray tribe, whatever the diversity of size and shape of the teeth, they are placed in several rows, and succeed each other uninterruptedly from behind.

In the genus *Rhina*, each tooth is supported on a short fang or pivot, which tapers as it recedes from the crown; there is a groove along the posterior part of the pivot, and a perforation on each side; the crown is lozenge-shaped, convex above, and sculptured with a series of transverse and slightly undulating and punctate ridges, presenting a pattern which somewhat resembles that of the grinding surface of the comparatively gigantic tooth of the extinct cartilaginous fish of the chalk formation called *Ptychodus*. The modification of the dentigerous surface of the jaws, and the beautiful quincuncial arrangement of these teeth, are exhibited in fig. 25.

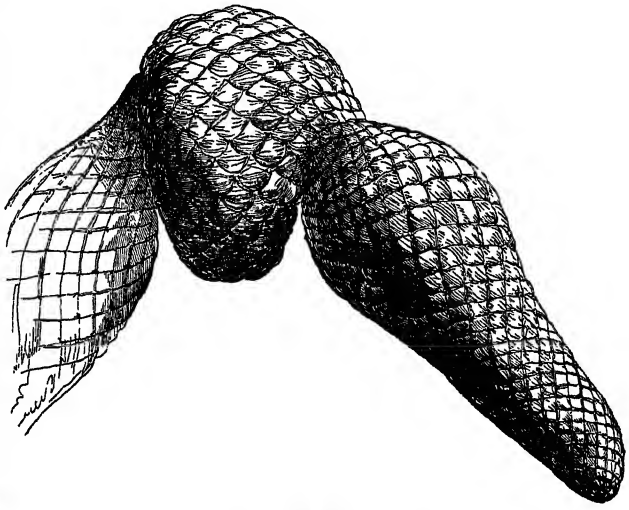

Fig. 25.
Dental Pavement of the Upper Jaw (*Rhina*).

The middle part of the upper jaw forms a bold prominent convexity, separated by a depression on each side from a lateral and less produced rising. The contour of the dentigerous surface of the lower jaw presents depressions corresponding to the eminences above, and *vice versa*.

The modification of the plagiostomous type of teeth, for the purpose of crushing alimentary substances, is most complete in the genus *Myliobates*. A view of this armature of the mouth, as seen from behind in the *Myliobates aquila*, is given in fig. 26. Both

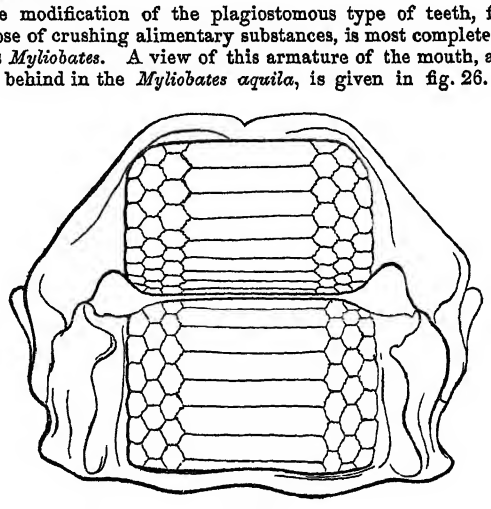

Fig. 26.
Jaws and Teeth of an Eagle-Ray (*Myliobates aquila*)

jaws are covered with a pavement of broad teeth, having a flat grinding surface, vertical and finely-undulated sides, by which

Teeth of Fishes.

contiguous teeth are joined together, as by a suture (fig. 27, *c*), and a base divided into a number of small parallel longitudinal ridges.

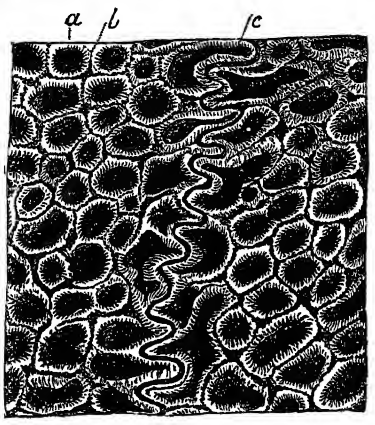

Fig. 27.
Magnified Section of parts of two contiguous Denticles of *Myliobates aquila*.

The entire phalanx of dental plates of the upper jaw describes the segment of a circle. A longitudinal and vertical section of a single dental plate, viewed by a compound lens of an inch focus, exhibits at its base a coarse network of large irregular canals, filled with a vascular medullary pulp. From this network smaller medullary canals proceed towards the flat grinding surface, in a straight and slightly diverging course, subdividing dichotomously, with interspaces equal to their own diameter at the base, but much wider at the working surface of the tooth; under the same power, the area of the medullary canals presents generally an irregular elliptical form (fig. 27, *a*), from which radiating dentinal tubes are faintly perceptible. Each canal and its series of tubes is surrounded by a line of generally a hexagonal form (fig. 27, *b*), which constitutes the boundary between contiguous canals and tubes; the whole tooth being thus composed of an aggregate of slender, elongated, commonly six-sided prismatic teeth, placed vertically to the grinding surface. The wavy line of the suture, uniting two contiguous teeth, is shown at *c*.

The teeth of the Myliobates, like those of the rest of the Plagiostomes, are successively formed at the posterior part of the tesselated series in proportion as they are worn away in front. A series of minute and closely-aggregated papilliform matrices rise from the mucous membrane behind the teeth, and are covered by a fold of the same membrane, which is reflected forward so as to conceal the pulps of the last-formed teeth. The papilliform pulps are ossified by the deposition of the calcareous salts in the peripheral cells and radiating tubes; but the medullary or central canal of each pulp continues to retain its organized and vascular contents until the whole of the compound tooth is completed; the calcified wall of the medullary canal is then thickened, and the area diminished, by the successive formation of concentric laminæ of osseous matter.

As the teeth of the *Myliobates* are gradually carried forwards into action by the direction of growth of their basis of support, the areæ of the medullary canals become progressively diminished, as in bone, by osseous deposition in concentric layers, and they thus become finally consolidated in the anterior teeth.

Cestracionts.

The dental characters of this family of cartilaginous fishes are chiefly manifested in a form of tooth better adapted for crushing or comminuting alimentary substances which offer only passive resistance, than for piercing, cutting, and lacerating a living prey; and in most of the species the teeth vary in form and size in the same individual to a greater degree than in the sharks. Of the numerous singular forms of this tribe of cartilaginous fishes that once peopled the seas of the Northern Hemisphere, and which have left their less perishable remains in the secondary strata of the present dry land, all have now disappeared, and the sole existing representative is the genus *Cestracion*, of which the most common species is met with in the Australian seas. The ancient fossils above alluded to would have been scarcely intelligible, unless the key to their nature had been afforded by the teeth and spines of the existing Cestracion. In the Port Jackson shark (*Cestracion Phillippii*), the jaws form a greater proportion of the skull than in any other existing cartilaginous and plagiostomous fish. They are also more elongated, and directed more horizontally forward, thus approaching nearer to the usual position of the jaws in the osseous fishes. The teeth are arranged, as in the Plagiostomes generally, in several antero-posterior rows along the margin and inner surface of both jaws (fig. 28); but the rows are more oblique than in the sharks, although less so than in certain rays,—*e.g.*, *Rhina*. The teeth of the upper jaw are delineated in fig. 28. Those at the anterior part of the jaws are the smallest; they present a transverse, subcompressed, conical figure, with the apex produced into a sharp point; the points are worn away from the used teeth at the anterior and outer parts of the jaw, but are strongly marked in those which still lie below the margin. There are six subvertical rows of these small cuspidate teeth on each side of the jaw, together with a median row close to the symphysial line, and there are from twelve to fourteen teeth in a row. Behind the cuspidate teeth the five consecutive rows of teeth progressively increase in all their dimensions, but principally in their antero-posterior extent. The sharp point is converted into a longitudinal ridge traversing a convex crushing surface, and the

Teeth of Fishes.

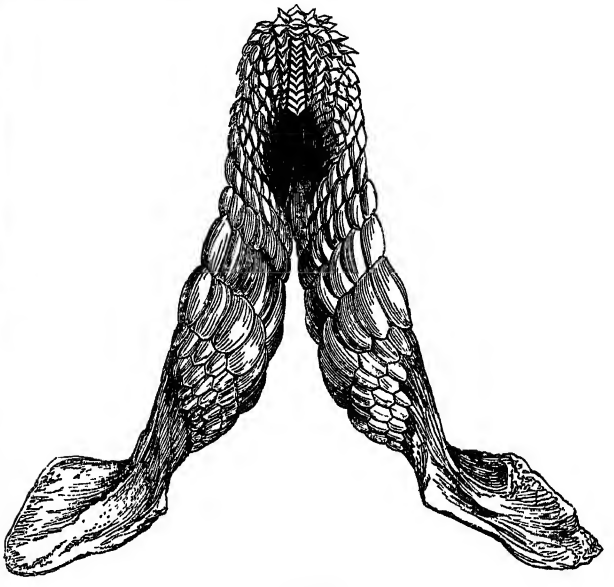

Fig. 28.
Upper Jaw and Teeth of Port Jackson Shark (*Cestracion*), half nat. size.

ridge itself disappears in the largest teeth. As the teeth increase in size, they diminish in number in each row. The series of the largest teeth includes from six to seven in the upper, and from seven to eight in the lower jaw. Behind this row the teeth, although preserving their form as crushing instruments, progressively diminish in size, while at the same time the number composing each row decreases. From the oblique and apparently spiral disposition of the rows of teeth, their symmetrical arrangement on the opposite sides of the jaw, and their graduated diversity of form, they constitute the most elegant tesselated covering to the jaws which is to be met with in the whole class of fishes.

The modifications of the form of the teeth above described, by which the anterior ones are adapted for seizing and retaining, and the posterior for cracking and crushing alimentary substances, are frequently repeated, with various modifications and under different conditions, in the osseous fishes. They indicate, in the present cartilaginous species, a diet of a lower organized character than in the true sharks; and a corresponding difference of habit and disposition is associated therewith. The testaceous and crustaceous invertebrate animals constitute most probably the principal food of the Cestracion, as they appear, by their abundant remains in secondary rocks, to have done in regard to the extinct Cestracionts, with whose fossil teeth they are associated.

From the extensive series of osseous fishes, the limits of the present article compel a selection of a few of the more remarkable modifications of the dental system.

Anarhicas.

Genus ANARHICAS.—The cat-fish or wolf-fish (*Anarhicas lupus*) has two kinds of teeth with well-marked distinction of form, according to which they might be termed laniaries or canines, and molars. The anterior teeth (fig. 29, *a*) form strong cones, and diverge so as to act as grappling hooks, well fitted for a firm grasp of the mailed body of a struggling lobster, or for extracting the shell-fish from his rocky recess or sandy burrow. The back teeth *c* are like paving-stones, and are powerful crushers. The premaxillary teeth (fig. 29, *a*) are all conical, and arranged in two rows; there are two, three, or four in the exterior row, at the mesial half of the bone, which are the largest; and from six to eight smaller teeth are irregularly arranged behind. There are three large, strong, diverging laniaries at the anterior end of each premandibular bone (fig. 29), and immediately behind these an irregular number of shorter and smaller conical teeth, which gradually exchange this form for that of large obtuse tubercles; these extend backwards, in a double alternate series, along a great part of the alveolar border of the bone, and are terminated by two or three smaller teeth in a single row, the last of which again presents the conical form. Each palatine bone supports a double row of teeth, the outer ones being conical and straight, and from four to six in number; the inner ones two, three, or four in number, and tuberculate. The lower surface of the vomer (fig. 29, *c*) is covered by a double

Teeth of Fishes.

irregularly alternate series of the same kind of large tuberculate crushing teeth as those at the middle of the premandibular bone.

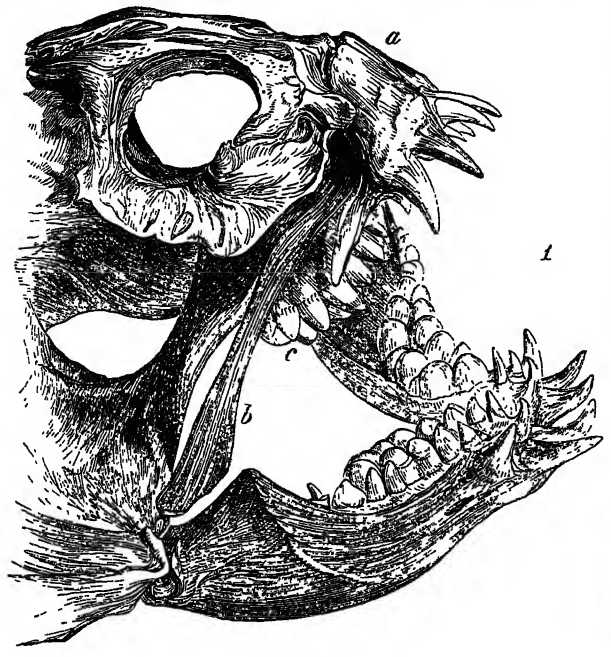

Fig. 29.
Upper and Lower Jaws and Teeth of the Wolf-fish (*Anarhicas lupus*), half nat. size.

All the teeth are anchylosed to more or less developed alveolar eminences, but a narrow line of demarcation is long discernible (as at 2, fig. 30). From the enormous development of the muscles

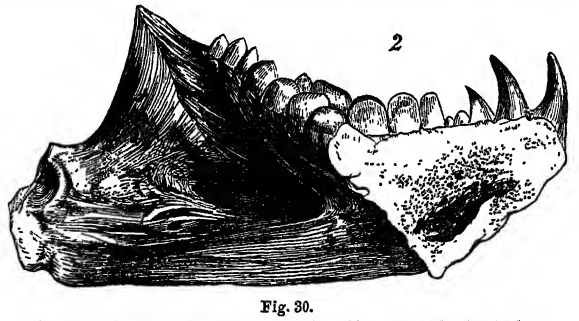

Fig. 30.
Section of Lower Jaw and Teeth of *Anarhicas lupus*, half nat. size.

of the jaws, and the strength of the shells which are cracked and crushed by the teeth, their fracture and displacement must obviously be no unfrequent occurrence: and most specimens of the jaws of the wolf-fish exhibit some of the teeth either separated at this line of imperfect anchylosis, or, more rarely, broken off above the base, or, still more rarely, detached by fracture of the supporting osseous alveolar process.

Lophius.

The angler (*Lophius piscatorius*) has teeth on the premaxillary, premandibular, palatine, vomerine, and pharyngeal bones. They are of an elongated, conical, sharp-pointed, and slightly incurved form, presenting merely difference of size, degree of curvature, and mode of fixation, but all bespeaking the predatory and carnivorous habits of the species. In the upper jaw, the teeth are congregated in three or four irregular rows at the median or upper third part of each premaxillary bone, and form a single and regular series along the lower two-thirds of the same bone. These latter, which may be termed the *serial teeth*, are from fifteen to eighteen in number; they are short, strong, pointed, and incurved, of nearly equal size, and placed at regular distances from each other. The two outer irregular rows of the median intermaxillary teeth are somewhat larger, and are directed forwards. The inner rows at this part contain the longest teeth, and their points are turned back; but they are movably connected with the bone by a mechanism which will be described when treating of those of the lower jaw. The superior pharyngeal teeth are arranged in three groups upon as many separate bones on each side; each group describes a curve, with the convexity turned forwards. The teeth of the posterior bone are the smallest. The inferior pharyngeal bones are two in number, and have the teeth arranged in a double alternate row along each margin.

Teeth of Fishes.

The pharyngeal, palatine, and vomerine teeth are fixed by anchylosis to their respective bones; this is also the case with most of the premaxillary teeth, and with the exterior teeth of the lower jaw (fig. 31, *a*, *a*), but the remainder, and especially the large posterior teeth of the lower jaw (fig. 31, *b*, *b*), are attached by means of elastic ligaments to the margins of slightly elevated alveolar processes. These ligaments (fig. 31, *c*, *c*) are principally inserted into the inner straight margin of the base of the tooth, from which their glistening fasciculi radiate to be implanted into the jaw. The rest of the base of the tooth is connected at its circumference with more lax and yielding fibrous bands, and with the mucous membrane of the mouth, which covers the alveolar tract in the interspaces of the teeth. To any attempt to bend these teeth outwards resistance is offered by the internal ligaments above described, and by the pressure of the anterior angle at the base of the tooth against the alveolar processes or raised tubercle on which it rests; but the tooth readily yields to a force acting in the opposite direction, and the

Cyprinidæ.

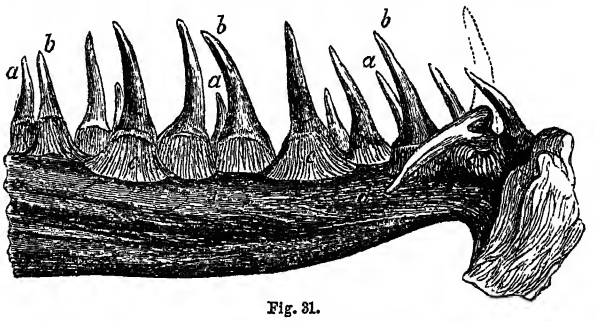

Fig. 31.
Section of Mandible and Teeth of the Angler (*Lophius piscatorius*).

largest and most prominent teeth can be bent inwards and backwards (as at *c*, fig. 31), so as to point to the gullet when the hand is pressed over them in the direction a body would take when drawn into the mouth to be swallowed. The moment, however, this force ceases to act, the teeth recoil to their erect position, as shown by the dotted outline in fig. 31) as if operated on by a spring. If everything attached to the base of the tooth, excepting the internal pyramidal band of ligamentous fibres, be removed, the tooth, after being bent down, returns with the same force to the erect position; it is therefore to this band that its resilience is due.

Cyprinidæ.

The cyprinoid fishes, properly so called, which are typified by the carp and loach, respectively representing the genera *Cyprinus* and *Cobitis*, have the jaws completely deprived of teeth. The inferior pharyngeals, or throat-bones, are armed with one or more rows of teeth, which are flattened, conical, or curved, according to the species. These are succeeded by teeth at the external, as the old are shed from the internal, surface of those bones. They work against each other, and upon the very hard callous or calcified plate which is fixed in a depression on the inferior surface of the basi-occipital bone. The omnivorous barbels (*Barbus* and *Labeobarbus*) have three rows of pharyngeal teeth, which are weaker in the latter genus. In *Acanthopsis* the pharyngeal teeth are sharp-pointed, and are placed in a single row. In the loaches (*Cobitis*), which feed on worms and aquatic insects, the pharyngeals are attenuated, with chisel-shaped extremities. In the gudgeons (*Gobio*), which feed on worms, aquatic larvæ, and small molluscous animals, with their ova or fry, the pharyngeal teeth are conical, slightly curved at the extremity, and arranged in two rows. In the carp (*Cyprinus Carpio*), which feeds on the soft part of aquatic plants, larvæ of insects and worms, the pharyngeal teeth have broad, flat-ridged crowns, like the molars of herbivorous quadrupeds.

Diodon.

In the globe-fishes (*Diodon*), the lamellated structure of the tooth, and its reproduction by successive transudation of layers from a persistent pulp, were supposed to be clearly demonstrated in the broad rounded triturating tubercule which is situated behind the alveolar border of the upper and lower jaw. The exposed surface of this tooth presents, in fact, a series of transverse and parallel striæ, which in a vertical section (fig. 32) are seen to be the margins of thin, superimposed, horizontal, and slightly flexuous plates *a*, *b*, which have been partially abraded by trituration in an oblique plane. The superior layers are the most worn; in proportion as they descend, in the lower jaw, they increase in breadth, and finally, instead of being soldered together, they become detached, thinner, and of a more friable texture; the lowest and incompletely developed plates lying loosely in the cavity of the jaw, beneath the superincumbent mass (as at *a*, fig. 32). If a vertical section of the dental tubercle be made on one side of the median plane, the

Teeth of Fishes.

laminæ are seen to be developed in two distinct lateral moieties, which become anchylosed together by means of a thin median vertical osseous partition at their median margins; their lateral margins are similarly anchylosed to the outer walls of the dentigerous cavity. The laminæ are developed successively; and in proportion as the anterior ones are worn away, the posterior ones appear in readiness to replace them; so that the due number of ridges on the triturating surface is always maintained.

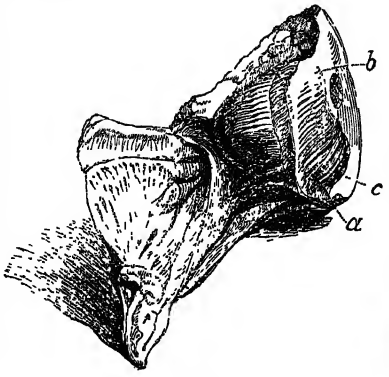

Fig. 32.
Section of Jaw and Dental Mass of a Globe-fish (*Diodon*).

To examine the structure of the lamelliform denticles, it is necessary to make extremely thin sections in a direction vertical to their plane. Each plane then exhibits, instead of an amorphous or subcrystalline mass of excreted calcareous matter, a series of extremely minute dentinal tubes, occupying its whole extent, and having a general direction vertical to its plane. The tubes are obviously wider at the lower side of the plate, and gradually disappear in the clear and dense substance at the opposite surface. When the thinnest and most transparent parts of the same section are examined with a compound lens of $\frac{1}{8}$-inch focus, the horizontal partitions which occupy the interspaces of the lamelliform teeth are seen to consist of a coarse cellular osseous texture, without any radiating cells, but similar to the texture of the rest of the endo-skeleton of the *Diodon*. The main tubes of the dental plate are continued immediately from the cells of the osseous septum; they proceed for a short distance vertically, or with a slight curvature, in the substance of the dental plate, and then quickly divide and subdivide, the branches generally coming off at an angle of 45°, being slightly bent, crossing each other in an inextricable manner, and terminating ultimately in the clear matrix of the upper surface of the dental plate. By the time that calcification has begun in one pulp, a second has been developed beneath it, and it is the portion of the pulp solidified which gives rise, in the macerated and dried jaws, to the loose and thin lamellæ in the dental cavity. These lamellæ become fixed by means of the coarser calcification or ossification which subsequently takes place in the remains of the pulp; and their margins are thus anchylosed to the surrounding bones in a manner analogous to the fixation of the base of the ordinary shaped teeth in other fishes.[1]

Scarus.

Genus SCARUS.—The dense tesselated covering of the beak-like jaws (fig. 33) of the parrot-fishes (*Scarus*) consists of a stratum of

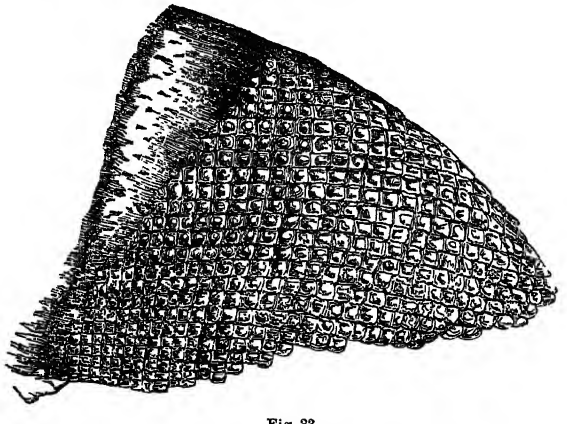

Fig. 33.
Premaxillary Bone and Teeth of a Parrot-fish (*Scarus muricatus*).

prismatic denticles (fig. 34, *a*), standing almost vertically to the external surface of the jaw-bone, the square tuberculate ends of which appear externally wedged close together, like the blocks in wood-pavement. This peculiar armature of the jaws is well adapted to the habits and exigences of a tribe of fishes which browse upon the lithophytes that clothe, as with a richly-tinted carpet, the bottom of the sea, just as the ruminant quadrupeds crop the herbage of the dry land.

Teeth of Fishes.

The irritable bodies of the gelatinous polypes, which constitute the food of these fishes, retract, when touched, into their star-shaped stony shells; and the *Scari* consequently require a dental apparatus strong enough to break off or scoop out these calcareous recesses. The jaws are therefore prominent, short, and stout; and the exposed portions of the premaxillaries and premandibulars are encased by the complicated dental covering represented in figs. 33 and 34. The polypes and their cells are reduced to a pulp by the

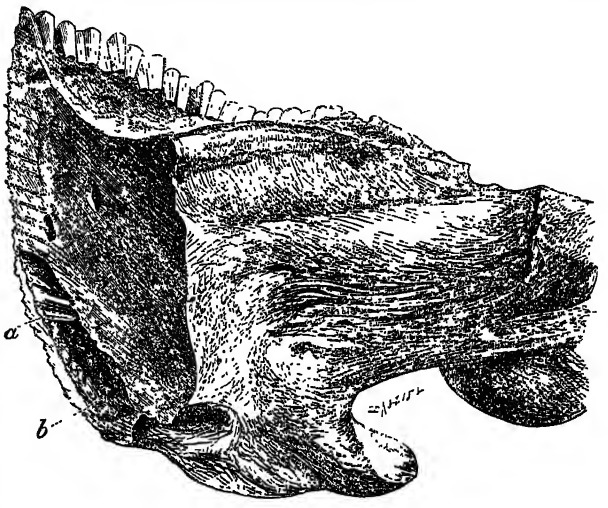

Fig. 34.
Section of Premandibular Bone and Teeth of Parrot-fish (*Scarus muricatus*).

action of the pharyngeal jaws and teeth (fig. 35) that close the posterior aperture of the mouth.

The typical *Scari* have both upper and lower pharyngeal bones paved with strong, thick lamelliform teeth, set vertically and transversely in the opposed surfaces of these bones. It is the posterior pair of the upper pharyngeals (fig. 35) which are thus armed. The lower pharyngeal bone is single.

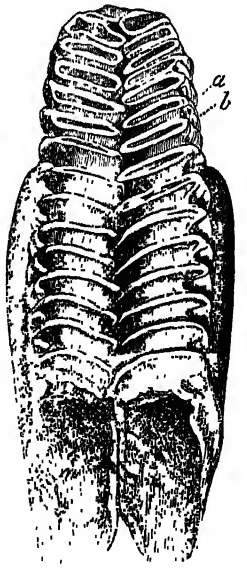

Fig. 35.
Upper Pharyngeal Bones and Teeth of a Parrot-fish (*Scarus muricatus*).

The superior dentigerous pharyngeals present each the form of an elongated vertical inequilateral triangular plate; the upper and posterior margin is sharp and concave; the upper and anterior margin forms a thickened articular surface, convex from side to side, and playing in a corresponding groove or concavity upon the base of the skull; the inferior boundary of the triangle is the longest, and also the broadest; it is convex in the antero-posterior direction, and flat from side to side. It is on this surface that the teeth are implanted; and in most species they form two rows, the outer one consisting of very small teeth (fig. 35, *a*), the inner one of large teeth *b*. These present the form of compressed conical plates or wedges, with the basis excavated and the opposite margin moderately sharp, and slightly convex to near the inner angle, which is produced into a point. These plates are set nearly transversely across the lower surface of the pharyngeal bone, and are produced beyond the margin of the bone, and interlock with those of the adjoining bone when the pharyngeals are in their natural position. The smaller denticles of the outer row are set in the external interspaces of those of the inner row.

The dentine of the pharyngeal teeth of the *Scarus* consists of dentinal tubes and a clear intermediate substance. The tubes average a diameter of $\frac{1}{20000}$th of an inch, and are separated by interspaces equal to twice their own diameter; and these tubes, on leaving the pulp-cavity, form a curve with the convexity turned towards the base of the tooth, and then bend slightly in the opposite direction; the sigmoid curve being most marked in the tubes at the base of the denticles, whilst those towards the apex become longer and

[1] For other details of the gymnodont dentition, see *Annales des Sciences Naturelles*, 2de série, tom. xii., p. 347.

Teeth of Fishes

straighter. Besides the primary curvatures exemplified in the figure, each dentinal tube is minutely undulated; it dichotomizes three or four times near its termination, sends off many fine lateral branches into the clear uniting substance, and finally terminates in a series of minute cells and inosculating loops, at the line of junction with the enamel.

This substance is as thick as the dentine, and consists of a similar combination of minute tubes and a clear connecting substance. The tubes may be described as commencing from the peripheral surface of the tooth, to which they stand at right angles; and having proceeded parallel to each other half-way towards the dentine, they then begin to divide and subdivide, the branches crossing each other obliquely, and finally terminating in the cellular boundary between the enamel and dentine.

The teeth which present this complex structure are successively developed at one extremity of the bone in proportion as they are worn away at the other—not, however, as Cuvier describes, from behind forwards in both upper and lower pharyngeal bones, but in opposite directions in the opposite bones, the course of succession being from before backwards in the upper, and from behind forwards in the lower pharyngeal bones. In the progress of the attrition to which they are subjected, the thin coat of cement resulting from the ossification of the capsule is first removed from the apex of the tooth, then the enamel constituting that apex, next the dentine, and finally the coarse central cellular bone supporting the hollow wedge-shaped tooth; and thus is produced a triturating surface of four different substances of different degrees of density. The enamel, being the densest element, appears in the form of elliptical transverse ridges inclosing the dentine and central bone; and external to the enamel is the cement which binds together the different denticles.

The single inferior pharyngeal bone consists principally of an oblong dentigerous plate. Its breadth somewhat exceeds that of the conjoined dentigerous surfaces of the pharyngeals above; and it is gently hollowed, to correspond with their convexity. This dentigerous plate is principally supported by a strong, slightly curved, transverse, osseous bar, the extremities of which expand into thick obtuse processes for the implantation of the triturating muscles. A longitudinal crest is continued downwards and forwards from the middle line of the inferior pharyngeal plate, anterior to the transverse bar, to which the protractor muscles are attached.

A longitudinal row of small oval teeth, alternating with the large lamelliform teeth, like those of the superior pharyngeals, bounds the dentigerous plate on each side. The intermediate space is occupied exclusively by the larger lamelliform or wedge-shaped teeth, set vertically in the bone, and arranged transversely in alternate and pretty close-set rows.

There is a close analogy between the dental mass of the *Scarus* and the complicated grinders of the elephant, both in form, structure, and in the reproduction of the component denticles in horizontal succession. But in the fish the complexity of the triturating surface is greater than in the mammal, since, from the mode in which the wedge-shaped denticles of the *Scarus* are implanted upon, and anchylosed to, the processes of the supporting bone, this likewise enters into the formation of the masticatory surface when the tooth is worn down to a certain point.

The proof of the efficacy of the complex masticatory apparatus above described is afforded by the contents of the alimentary canal of the *Scari*. Mr Charles Darwin, the accomplished naturalist and geologist, who accompanied Captain Fitzroy, R.N., in the circumnavigatory voyage of the Beagle, dissected several parrot-fishes soon after they were caught, and found the intestines laden with nearly pure chalk, such being the nature of their excrements; whence he ranks these fishes among the geological agents to which is assigned the office of converting the skeletons of the lithophytes into chalk.

Sphyræna.

Genus SPHYRÆNA.—The most formidable dentition in the order of osseous fishes is that which characterizes the Barracuda sea-pikes (*Sphyræna*), and some extinct fishes allied to this predatory genus. In the great Barracuda of the southern shores of the United States (*Sphyræna barracuda*, Cuv.), the lower jaw contains a single row of large, compressed, conical, sharp-pointed, and sharp-edged teeth, resembling the blades of lancets, but stronger at the base. The two anterior of these teeth are twice as long as the rest; but the posterior and serial teeth gradually increase in size towards the back part of the jaw. There are about twenty-four of these piercing and cutting teeth in each premandibular bone. They are opposed to a double row of similar teeth in the upper jaw, and fit into the interspace of these two rows when the mouth is closed. The outermost row is situated on the premaxillary, the innermost on the palatine bones. There are no teeth on the vomer or superior maxillary bones. The two anterior teeth in each premaxillary bone equal the opposite pair in the lower jaw in size; the posterior premaxillary teeth are serial, numerous, and of small size; the second of the two anterior large premaxilliary teeth is placed on the inner side of the commencement of the row of small teeth, and is a little inclined backwards. The retaining power of all the large anterior teeth is increased by a slight posterior projection, similar to the barb of a fish-hook, but smaller. The palatine bones contain each nine or ten lancet-shaped teeth, somewhat larger than the posterior ones of the lower jaw. All these teeth afford good examples of the mode of attachment by implantation in sockets, which is a rare one in the class of fishes.

Teeth of Fishes.

The base or fang of the fully-developed tooth of the *Sphyræna* is anchylosed to the parietes of the socket in which it is inserted. The pressure of the crown of the new tooth excites absorption of the inner side of the base of the old, which thus finally loses the requisite strength of attachment, and its loss is followed by the absorption of the old socket, as in the higher animals.

It is interesting to observe that the external teeth are in general contemporaneously shed, so that the maxillary armour is always preserved in an effective state. The relative position of the new teeth to their predecessors, and their influence upon them, resembles some of the phenomena which will be described in the dentition of the crocodilian reptiles. To the crocodiles the present voracious fish also approximates in the alveolar lodgment of the teeth; but it manifests its ichthyic character in the anchylosis of the fully-developed teeth to their sockets, and still more strikingly in the intimate structure of the teeth. The loss or injury to which these destructive weapons are liable in the conflict which the *Sphyræna* wages with its living and struggling prey is repaired by an uninterrupted succession of new pulps and teeth. The existence of these is indicated by the foramina, which are situated immediately posterior to, or on the inner margins of, the sockets of the teeth in place. These foramina lead to alveoli of reserve, in which the crowns of the new teeth, in different stages of development, are loosely imbedded. It is in this position of the germs of the teeth that the sphyrænoid fishes, both recent and fossil, mainly differ as to their dental characters from the rest of the scomberoid family, and proportionally approach the sauroid type.

In all fishes the teeth are shed and renewed, not once only, as in mammals, but frequently during the whole course of their lives. The maxillary dental plates of *Lepidosiren*, the cylindrical dental masses of the chimæroid and edaphodont fishes, and the rostral teeth of the *Pristis* (if these modified dermal spines may be so called), are perhaps the sole examples of permanent teeth to be met with in the whole class. In the great majority of fishes the germs of the new teeth are developed, like those of the old, from the free surface of the buccal membrane throughout the entire period of succession; a circumstance peculiar to the present class. The angler, the pike, and most of our common fishes, illustrate this mode of dental reproduction; it is very conspicuous in the cartilaginous fishes, in which the whole phalanx of their numerous teeth is ever marching slowly forwards in rotatory progress over the alveolar border of the jaw; the teeth being successively cast off as they reach the outer margin, whilst the new teeth rise from the mucous membrane behind the rear rank of the phalanx. This endless succession and decadence of the teeth, together with the vast numbers in which they often co-exist in the same fish, illustrate the law of "vegetative" or "irrelative repetition," as it manifests itself on the first introduction of new organs in the animal kingdom; under which light we must view the above-described organized and calcified preparatory instruments of digestion in the lowest class of the vertebrate series.

Lepidosiren.

At the extreme limit of the class of fishes, and connecting that class with the reptiles, stands the very remarkable genus, the dental system of which is shown in fig. 36. This consists of two small,

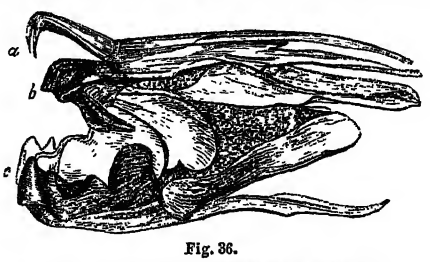

Fig. 36.

Skull and Teeth of the *Lepidosiren annectens*.

slender, conical, sharp-pointed, and slightly recurved teeth, which project downward from the nasal bone *a*, and of strong trenchant dental plates, anchylosed with the alveolar border of the upper (*b*) and lower (*c*) jaw, in each of which the plate is divided at the middle or symphysial line, so as to form two distinct lateral teeth.

The office of the two laniariform teeth is to pierce and retain the

Teeth of Reptiles.

nutritive substance or prey, which is afterwards divided and comminuted by the strong maxillary dental plates. The upper pair of these plates is supported by the anterior part of a strong arch of bone, which combines the character of the superior maxillary, palatine, and pterygoid bones. The superior maxillary is represented by the median and anterior bar, passing in front of the dental plate of the lower jaw when the mouth is shut, and terminating on each side in a process which projects outwards and backwards on each side of the anterior part of the arch; the palatine portion constitutes the median part of the roof of the mouth behind the foregoing. The pterygoid portion is indicated by its fulfilling the usual function of an abutment extended between the palatine portion of the upper jaw and the articular pedicle of the lower jaw. The upper dental plates are confined to the first two parts of the arch (maxillary and palatine), and do not extend upon the pterygoid portion; the lower dental plates are anchylosed to the premandibular bone. Viewing the upper pair of plates as a single tooth, it may be described as indented at its outer surface by five vertical angular notches, penetrating inwards through half the breadth of the supporting bone, and dividing the plate into six angular processes, which, from the direction and varying form and breadth of the entering notches, radiate from the posterior part of the median line or division of the tooth. The inferior dental plate is similarly notched on its outer side, but the proportions of the angular indentations are such that they receive all the processes of the upper dental plate when the mouth is shut, whilst only the four anterior processes are reciprocally received into the notches of the upper dental plate. The dental plate consists, as in the cod and *Sphyræna*, of a central mass of coarse osseous substance traversed by large and nearly parallel medullary canals, and an external sheath of very hard "vitrodentine."

Dendrodonts.

The labyrinthic structure of the teeth of the bony gar-fish of the North American lakes and rivers (*Lepidosteus*) has been already alluded to in the introductory generalization on dental tissues. The still more complex structure of the fossil teeth of the extinct Dendrodonts (fig. 14) is there more fully described. As compared with the vasodentine (fig. 7) of the sharks and of many existing osseous fishes, the dental tissue of the Dendrodonts differs in both the extent and regularity of the radiating medullary canals, and more especially in the straight course of the fine dentinal tubes.

Both the foregoing genera of fishes have been termed "sauroid," but are more truly "salamandroid," and approach, like the Lepidosiren, most closely to the lower confines of the reptilian class; and as this existing annectant genus is allied to the perennibranchiate Batrachians, so the *Dendrodus* may have linked some extinct group of the class of fishes with the equally extinct family of sauroid Batrachians which have been termed "Labyrinthodonts."

Sect. II.—TEETH OF REPTILES.

In the class Reptilia, the whole order of *Chelonia* is edentulous, as well as the family of toads (*Bufonidæ*), in the order *Batrachia;* certain extinct genera of Saurians were edentulous, *e.g.*, the remarkable *Rhynchosaurus* of the New Red Sandstone of Shropshire, and some of the extinct Saurians of South Africa.

In the tortoises and turtles, the jaws are covered by a sheath of horn, which in some species is of considerable thickness, and very dense; its working surface is trenchant in the carnivorous species, but variously sculptured, and adapted for both cutting and bruising, in the vegetable feeders; it may be said that the transitory condition of the mandibles of the batrachian larvæ is here persistent. The development of the continuous horny maxillary sheath commences, as in the parrot tribe, from a series of distinct papillæ, which sink into alveolar cavities, regularly arranged (in *Trionyx*) along the margins of the upper and lower jaw-bones; these alveoli are indicated by the persistence of vascular canals long after the originally separate tooth-like cones have become confluent and the horny sheath completed. The teeth of the dentigerous saurian, ophidian, and batrachian reptiles are for the most part simple, and adapted for seizing and holding, but not for dividing or masticating their food. The siren alone combines true teeth with a horny maxillary trenchant sheath, like that of the chelonian reptiles. Teeth of Reptiles.

With respect to *number*, in no existing reptiles are the teeth reduced so low as in certain mammals and fishes; nor, on the other hand, are they ever so multiplied as in many of the latter class. The extinct dicynodont reptiles of South Africa had but two teeth, which were long tusks implanted in the upper jaw (fig. 44).[1] Some species of *Amphisbæna* (*A. alba*), with fifteen teeth in the upper jaw and fourteen in the lower, afford examples of the smallest number of teeth amongst existing reptiles; and certain Batrachians, with teeth "en cardes" at the roof of the mouth, or which have upwards of eighty teeth in each lateral maxillary series, present the largest number. It is rarely that the number of the teeth is fixed and determinate in any reptile, so as to be characteristic of the species; and still more rarely have the individual teeth such characters as to be determined homologically from one species to another. Number.

The teeth of reptiles, with few exceptions, present a simple conical *form*, with the crown more or less curved, and the apex more or less acute. The cone varies in length and thickness; its transverse section is sometimes circular, but more commonly elliptical or oval, and this modification of the cone may be traced through every gradation, from the thick, round, canine-like tooth of the crocodile, to the sabre-shaped fang of the Varanus, the Megalosaur, and Cladeiodon.[2] Sometimes, as in the fully-formed teeth of the Megalosaur, one of the margins of the compressed crown of the tooth is trenchant, sometimes both are so; and these may be simply sharp-edged, as in the Varanus of Fimor, or finely serrated, as in the great Varanus, the Cladeiodon, and the Megalosaur.[3] Form.

The outer surface of the crown of the tooth is usually smooth: it may be polished, as in the Leiodon; or impressed with fine lines, as in the Labyrinthodon (fig. 11); or raised into many narrow ridges, as in the Pleiosaur and Polyptychodon; or broken by a few broad ridges, as in the Iguanodon (fig. 42); or grooved by a single longitudinal furrow, as in some lizards and serpents (fig. 38).[4]

The cone is longest, and its summit sharpest, in the serpent; from these may be traced, chiefly in the lizard tribe, a progressive shortening, expansion of the base, and blunting of the apex of the tooth, until the cone is reduced to a hemispherical tubercle or plate, as in the Thorictes and Cyclodus. The extinct *Placodus* was remarkable for the great size of its flat crushing teeth; in one species (*Pl. laticeps*) the diameter of the crown of the last palatal tooth is one inch four lines, the length of the skull being eight inches: this is the largest proportional grinding-tooth in the animal kingdom. In the Pleiosaur, the dental cone is three-sided, with one of the angles rounded off. The posterior subcompressed teeth of the alligator (fig. 46) present a new modification of form; here they terminate in a mammillate summit, supported by a slightly constricted neck. In the tooth of the Hylœosaur the expanded summit is flattened, bent, and spear-shaped, with the edges blunted. But the breadth of the compressed crown is greatest in the subcompressed teeth of the extinct Cardiodon and the existing Iguanas, the teeth of which latter reptiles are further complicated by having the margins notched. The great Iguanodon had the crown of the tooth expanded both in length and breadth, and combined marginal dentations with longitudinal ridges; this tooth (fig. 42) presents the most complicated external form as yet discovered in the class of reptiles. In no reptiles does the base of the tooth ever branch into fangs.

With respect to *situation*, the teeth may be present on Situation.

[1] *Transactions of the Geological Society*, 2d series, vol. vii., p. 59.
[2] *Odontography*, pl. lxii. A, fig. 4.
[3] Ibid., fig. 60.
[4] Ibid., pl. lxv.

Teeth of Reptiles.

the jaws only,—viz., the maxillary, premaxillary, and mandibular bones, as in the crocodiles, and many lizards; or upon the jaws and roof of the mouth; and here, either upon the pterygoid bones, as in the Iguana and Mosasaur; or upon both palatine and pterygoid bones, as in most serpents; or upon the vomer, as in most Batrachians; or upon both vomerine and pterygoid bones, as in the Axolotl; or upon the vomerine and phenoid bones, as in the *Salamandra glutinosa*, Maclure. With respect to the marginal or jaw teeth, these may be absent in the premaxillary bones, as in many serpents; or they may be present in the upper and not in the lower jaw, as in most frogs; or in both upper and lower jaws, as in the tailed Batrachians; and among these they may be supported, upon the lower jaw, by the premandibular or dentary piece, as in the Salamander, Menopome, Amphiume, Proteus; or upon the splenial piece,[1] as in the Siren; or upon both the splenial and premandibular bones, as in the Axolotl. The palatine and pterygoid teeth may, in the Batrachians, be arranged in several rows, like the "dents en cardes" of fishes. The sphenoid and splenial teeth are always so arranged in the few species that possess them. The premaxillary, maxillary, and premandibular teeth are uniserial, or in one row, with the exception of the *Cæcilia*, and the extinct Labyrinthodonts, which have a double row of teeth at the anterior part of the lower jaw.

Attachment.

As a general rule, the teeth of reptiles are anchylosed to the bone which supports them; when they continue distinct, they may be lodged either in a continuous groove, as in the Ichthyosaurs,[2] or in separate sockets, as in the Plesiosaurs and crocodiles (fig. 46).

The base of the tooth is anchylosed to the walls of a moderately deep socket in the extinct Megalosaur and Theocodon. In the Labyrinthodonts and Cæciliæ, among the Batrachians, in most Ophidians,—and in the Geckos, Agamians, and Varanians, among the Saurians,—the base of the tooth is imbedded in a shallow socket, and is confluent therewith. In the Scincoidians, the safeguards (*Tejus*) in most Iguanians, in the Chameleons, and most other lacertian reptiles, the tooth is anchylosed by an oblique surface, extending from the base, more or less, upon the outer side of the crown, to an external alveolar plate of bone,[3] the inner alveolar plate not being developed. In the frogs, the teeth are similarly but less firmly attached to an external parapet of bone. The lizards, which have their teeth thus attached to the side of the jaw, are termed "Pleurodont." In a few Iguanians, as the Istiures, the teeth appear to be soldered to the margins of the jaws; these have been termed "Acrodonts." In some large extinct Lacertians,—*e.g.*, the Mosasaur and Leiodon,—the tooth is fixed upon a raised conical process of bone, as shown in the author's "Odontography," plate 68, fig. 1; and plate 72, fig. 2.

These modifications of the attachment of the teeth of reptiles are closely adapted to the destined application of those instruments, and relate to the habits and food of the species: we may likewise perceive that they offer a close analogy to some of the transitory conditions of the human teeth. There is a period, for example,[4] when the primitive dental papillæ are not defended by either an outer or an inner alveolar process, any more than their calcified homologues, which are confluent with the margin of the jaw in the Rhynchocephalus.[5] There is another stage,[6] in which the groove containing the dental germs is defended by a single external cartilaginous alveolar ridge; this condition is permanently typified in the *Cyclodus*, and most existing lizards (fig. 41). Next, there is developed in the human embryo an internal alveolar plate, and the sacs and pulps of the teeth sink into a deep but continuous groove, in which traces of transverse partitions soon make their appearance: in the ancient Ichthyosaur the relation of the jaws to the teeth never advance beyond this stage. Finally, the dental groove is divided by complete partitions,[7] and a separate socket is formed for each tooth; and this stage of development is attained in the highest organized reptiles—*e.g.*, the crocodiles.

Teeth of Reptiles.

Substance.

The tissues entering into the composition of reptilian teeth may be four-fold, and a single tooth may be composed of dentine, cement, enamel, and bone; but the dentine and cement are present in the teeth of all reptiles. In the Batrachians and Ophidians a thin layer of cement invests the central body of dentine, and, as usual, follows any inflections or sinuosities that may characterize the dentine. Besides the outer coat of cement, which is thickest at the base of the teeth, a generally thin coat of enamel defends the crown of the tooth in most Saurians, and the last remains of the pulp are not unfrequently converted into a coarse bone, both in the teeth which are anchylosed to the jaw, and in some teeth, as those of the Ichthyosaur, which remain free. The only modification of the dentine, which could at all entitle it to be regarded in the light of a new or distinct substance, is that which is peculiar in the present class to the teeth of the Iguanodon, and which will be presently described.

Structure.

The varieties of dental structure are few in the reptiles, as compared with either fishes or mammals, and its most complicated condition arises from interblending of the dentinal and other substances, rather than from modifications of the tissues themselves. In the teeth of most reptiles, the intimate structure of the dentine corresponds with that which has been described as the type of the tissue,—*e.g.*, the hard or unvascular dentine,—and which is the prevailing modification in mammals, viz.,—the radiation of a system of minute plasmatic tubes from a single pulp-cavity, at right angles to the external surface of the tooth. The most essential modification of this structure is the intermingling of cylindrical processes of the pulp-cavity in the form of medullary canals, with the finer tubular structure.[8] Another modification is that in which the dentine maintains its normal structure, but is folded inwardly upon itself, so as to produce a deep longitudinal indentation on one side of the tooth. It is the expansion of the bottom of such a longitudinal deep fold that forms the central canal of the venom-fang of the serpent; but a glance at fig. 39 will show that, notwithstanding the singularly modified disposition of the dentine (*b*), its structure remains unaltered; and although the pulp-cavity (*p*) is reduced to the form of a crescentic fissure, the dentinal tubes continue to radiate from it according to the usual law. By a similar inflection of many vertical longitudinal folds of the external cement and external surface of the tooth, at regular intervals around the entire circumference of the tooth, and by a corresponding extension of radiated processes of the pulp-cavity and dentine into the interspaces of such inflected and converging folds, a modification of dental structure is established in certain extinct reptiles, which, by the various sinuosities of the interblended folds of cement, and processes of dentine, with the partial dilations of the radiated pulp-cavity, produces the complicated structure, which has been described at page 412, and figured in cut 12. But this complication is, nevertheless, referable to a modification of form or arrangement of the dental tissues, rather than of their number in the same tooth: the dentinal tubes in each

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[1] "Opercular bone" of Cuvier (in reptiles). [2] *Odontography*, pl. xiii., fig. 9. [3] Ibid., pl. lxvii.
[4] At the sixth week of gestation. See Prof. Goodsir "On the Development of the Human Teeth," *Edinburgh Medical and Surgical Journal*, No. 138. [5] *Geological Transactions*, 2d Series, vol. vii., pt. ii., pl. vi., figs. 5 and 6, p. 83.
[6] At the seventh or eighth week. (Ibid.) [7] At the sixth month. (Ibid.) [8] *Odontography*, pl. lxxi., "Iguanodon."

Teeth of Reptiles.

sinuous lobe of dentine in the most complex tooth of the *Labyrinthodon* exhibit the same general disposition and course as in the fang of the serpent, and in the still more simple tooth of the Saurian.

Development.

The teeth of reptiles are never completed, as in certain fishes, at the first or papillary stage; the pulp in all sinks into a follicle, and becomes inclosed by a capsule: in certain reptiles this becomes more or less surrounded by bone; but in the existing species the process of development never offers the "eruptive stage," in the sense in which this is usually understood, as signifying the extrication of the young tooth from a closed alveolus. The completion of a tooth, with the exception of the extinct dicynodont reptiles, is soon followed by preparation for its removal and succession: the faculty of developing new tooth-germs seems to be unlimited in the present class, and the phenomena of dental decadence and replacement are manifested at every period of life. The number of teeth is generally the same in each successive series, and the difference of size presented by the teeth of different and distinct series is considerable. The new germ is always developed, in the first instance, at the side of the base of the old tooth, never in the cavity of the base: the crocodiles form no exception to this rule. The poison-fangs of serpents succeed each other from behind forwards: in almost every other instance the germ of the successional tooth is developed from the bottom and towards the outer side of a small fissure in the mucous membrane or gum that fills up the shallow groove at the inside of the alveolar parapet and its adherent teeth; the papilla is soon enveloped by a capsular process of the surrounding membrane; a small enamel-pulp is developed in the matrix opposite the apex of the tooth; the deposition of the earthy salts in this mould is accompanied by ossification of the capsule, which afterwards proceeds *pari passu* with the calcification of the dentinal papilla or pulp; so that, with the exception of its base, the surface of the uncalcified part of the pulp alone remains normally unadherent to the capsule. As the tooth acquires hardness and size, it presses against the base of the contiguous attached tooth, causes a progressive absorption of that part (fig. 46, *a*), and finally undermines, displaces, and replaces its predecessor. The number of nascent matrices of the successional teeth is so great in the frog, and they are crowded so close together, that it is not unusual to find the capsules of contiguous tooth-germs becoming adherent together as their calcification proceeds. After a brief maceration, the soft gum may be stripped from the shallow alveolar depression, and the younger tooth-germs in different stages of growth are brought away with it.

The mode of development of the teeth of serpents does not differ essentially from that of the teeth of the Batrachians above described, except in the relation of the papillæ of the successional poison-fangs to the branch of the poison-duct that traverses the cavity of the loose mucous gum in which they are developed.

Batrachia.

The variations which the dental system presents in the Batrachian order of reptiles are more conspicuous in the number, situation, and structure of the teeth, than in their form or mode of attachment.

Certain Batrachians are edentulous, as the genus *Hylaplesia*, among the tree frogs, and the *Bufonidæ*, or family of toads—some of the species of *Bombinator* excepted.

The teeth, when present, are generally numerous, simple, of small and equal size, and close-set, either in a single row, or aggregated like the teeth of a rasp.

It is not without interest to observe, that a characteristic condition of the dental system in fishes—viz., the absence of teeth on the superior maxillary bone,—is continued in those genera of perennibranchiate Batrachians which stand at the lowest steps of the reptilian class.

In the Siren (*Siren lacertina*, Linn.), the lower margin of the intermaxillary bones, and the sloping anterior and upper margin of the lower jaw, are trenchant, and are each incased in a sheath of firm, albuminous, minutely fibrous tissue, harder than horn. The bones thus armed slide upon each other like the blades of a pair of curved scissors, when the mouth is closed, and are well adapted for dividing the bodies of small fish, aquatic larvæ, worms, &c. The splenial or opercular element in the jaw is beset with numerous minute pointed teeth, arranged in short oblique rows, and directed obliquely backwards. The palatal surface of the mouth presents on each side two flat, thin, and moderately broad bones, forming an apparently single oblique oval plate, which converges to meet its fellow at the anterior part of the palate, so as conjointly to constitute a broad rasp-like surface in the form of a chevron. The anterior long plate on each side of the divided vomer, supports six or seven oblique rows of small pointed retroverted teeth; the smallest posterior plate, probably the homologue of the pterygoid, is beset with four rows of similar teeth; there being thus ten or eleven rows on each side of the palatal chevron. The number of denticles in the middle rows is eleven or twelve; these become fewer in the anterior and posterior rows; they are all of similar size and form, corresponding with those of the lower jaw, to which they are opposed.

Teeth of Reptiles.

The condition of the dental system in this, the lowest of the Batrachia is not without interest, independently of the absence of the superior maxillary teeth, and of the presence of the palatal and inferior maxillary rasp-teeth (*dents en cardes*). The maxillary sheaths of the Siren being composed of horn, and being, moreover, easily detached from the subjacent bones, closely resemble the deciduous mandibles of the tadpoles of the higher Batrachians.

The *Proteus anguinus*, though retaining its external gills, offers a further advance to the dental characters of the higher Batrachians. The alveolar border of each intermaxillary bone is armed with a row of eight or ten minute and fine sharp-pointed teeth; each premandibular bone supports a greater number of similar but larger teeth, likewise arranged in a single row. The vomerine bones support a row of denticles, similar, and parallel to, the intermaxillary crescentic series: but the horns of the palatine dental crescent are continued much farther back, and terminate, as in the *Menobranchus*, on the anterior part of the pterygoid bones; each half of the crescentic or chevron-shaped series contains twenty-four teeth. The superior maxillary bones are represented in the Proteus by mere cartilaginous rudiments.

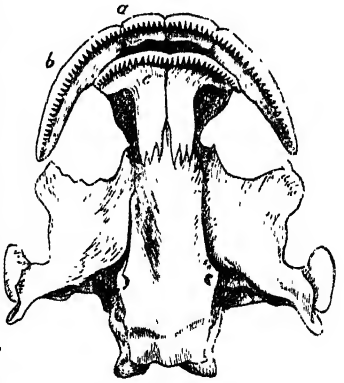

Fig. 37.
Cranium and Upper Jaw and Teeth of the Menopome. (*Menopoma alleghanniense*).

The Menopome makes a nearer approach to the caducibranchiate group, and allies itself most closely with the gigantic newt of Japan (*Sieboldtia*, Bonap.), and with that equally gigantic extinct species of newt so noted in Palæontology, as the "*Homo diluvii testis*" of Scheuchzer. The single close-set series of small, equal, conical, and slightly recurved teeth describes a semicircle on both the upper and the lower jaws; in the former the majority are supported by true maxillary bones *b*, about eight or ten on the premaxillaries *a*. The row of similar but smaller teeth on the anterior expanded border of the divided vomer *c* runs parallel with, and at a short distance behind, the median part of the maxillary series. The premandibular teeth are received into the narrow interspace

Teeth of Reptiles.

between the two rows in the upper jaw when the mouth is closed. The teeth of the Menopome, as of the Amphiume are anchylosed by their base and part of the outer side to a slightly elevated external alveolar ridge.

Genus LABYRINTHODON.—The dental system in this extinct genus is more formidable than in any existing Batrachian, the teeth being implanted in distinct sockets, and a few of the anterior ones developed into large tusks (fig. 11).

A close-set series of subsequent teeth extends along the alveolar border of both upper and lower jaws, and along the anterior part of the outer margin of each broad vomerine bone. Both the division and dentigerous character of this bone exemplify the batrachian affinities of the reptiles in question. Two or three canine-shaped teeth, at least three times the size of the serial teeth, are placed in the premaxillary bones, also at the anterior and external angle of each vomer, at the fore-part of the maxillaries, and behind the anterior extremity of the serial teeth of the lower jaw. This allocation of teeth in a double row is peculiar, among reptiles, to the Cecilia and the present equally aberrant form of Batrachian: it is a common dental character in the class of fishes.

But the remarkable characteristic of the teeth of the Labyrinthodonts is the complex structure described in the general introduction, and illustrated in fig. 12. By this character the author, in 1841,[1] determined the nature of certain fossil teeth which had been found in a member of the New Red Sandstone series in Warwickshire, but which were of extreme rarity in that formation in England. The geological evidence at that period had left it uncertain whether this light-coloured sandstone was the equivalent of the "Keuper" or "Bunter" division of the German Trias.[2]

So far as the geological question depended upon the determination of the generic identity of the reptilian fossils in the English and German formations, it supported the view entertained by certain geologists as to the correspondence of the Warwick sandstones with the Keuper sandstones of Germany. And if, on the one hand, geology has in this instance derived any benefit from microscopical investigations of animal tissues, on the other hand it must be admitted, that in no instance has comparative anatomy been more directly indebted to geology than for the fossils, and the stimulus to their microscopic investigation, by means of which a knowledge has been obtained of the most beautiful and complicated modification of dental structure hitherto known, and of which no adequate conception could have been gained from investigations, however close and extensive, of the teeth of existing species of animals.

Ophidia.

The order *Ophidia*, as it is characterized in the system of Cuvier, requires to be divided into two sections, according to the nature of the food, and the consequent modification of the jaws and teeth. Certain species, which subsist on worms, insects, and other small invertebrate animals, have the tympanic pedicle of the lower jaw immediately and immovably articulated to the walls of the cranium. The lateral branches of the lower jaw are fixed together at the symphysis, and are opposed by the usual vertical movement to a similarly complete maxillary arch above; these belong to the genera *Amphisbæna* and *Anguis* of Linnæus, the latter represented by our common slow-worm. The rest of the Ophidians, including the ordinary serpents and constrictors, which form the typical members, and by far the greatest proportion of the order, prey upon living animals of frequently much greater diameter than their own; and the maxillary apparatus is conformably and peculiarly modified to permit of the requisite distension of the soft parts surrounding the mouth, and the transmission of their prey to the digestive cavity.

In the present article the description will be restricted to the dental peculiarities of the true serpents. All these subsist on animal matter, and swallow their food whole, whether they prey on living animals, as is the case in almost every species, or feed on the eggs of birds, as in the *Deirodon scaber*, O. (*Coluber scaber*, Linn.)

Teeth of Reptiles.

With the exception of this and some congeneric species, in which the teeth of the ordinary bones of the mouth are so minute as to have been deemed wanting, the maxillary and premandibular bones in all true Ophidians are formidably armed with sharp-pointed teeth; there is on each side of the palate a row of similar teeth supported by the palatine and pterygoid bones. In the great Pythons, and some species of boa, the premaxillary bone also supports teeth. All the teeth, whatever be their position, present a simple conical form, the cone being long, slender, and terminated by an acute apex, and the tooth is either straight, or, more commonly, bent a little beyond the base, or simply recurved, or with a slight sigmoid flexure. The teeth are thus adapted for piercing, tearing, and holding, and not for dividing or bruising. In some species certain teeth are traversed by a longitudinal groove for conveying an acrid saliva into the wounds which they inflict; in others, two or more teeth are longitudinally perforated for transmitting venom; such teeth are called "poison-fangs" (fig. 38, *b*), and are always confined to the superior maxillaries, and are generally placed near the anterior extremity of those bones.

In the genus *Deirodon*, the teeth of the ordinary bones of the mouth are so small as to be scarcely perceptible, and they appear to be soon lost; so that it has been described as an edentulous serpent. An acquaintance with the habits and food of this species has shown how admirably this apparent defect is adapted to its wellbeing. Its business is to restrain the undue increase of the smaller birds by devouring their eggs. Now, if the teeth had existed of the ordinary form and proportions in the maxillary and palatal regions, the egg would have been broken as soon as it was seized, and much of its nutritions contents would have escaped from the lipless mouth of the snake in the act of deglutition; but, owing to the almost edentulous state of the jaws, the egg glides along the expanded opening unbroken, and it is not until it has reached the gullet, and the closed mouth prevents any escape of the nutritious matter, that the shell is exposed to instruments adapted for its perforation. These instruments consist of the inferior spinous processes of the seven or eight posterior cervical vertebræ, the extremities of which are capped by a layer of hard cement, and penetrate the dorsal parietes of the œsophagus. They may be readily seen, even in very young subjects, in the interior of that tube in which their points are directed backwards. The shell being sawed open longitudinally by these vertebral teeth, the egg is crushed by the contractions of the gullet, and is carried to the stomach, where the shell is no doubt soon dissolved by the acid gastric juice.

In the boa-constrictor, the teeth are slender, conical, suddenly bent backwards and inwards above their base of attachment, with the crown straight or very slightly curved, as in the posterior teeth. The premaxillary bone supports four small teeth; each superior maxillary bone has eight much larger ones, which gradually decrease in size as they are placed farther back. There are eight or nine teeth of similar size and proportions in each premandibular bone. These teeth are separated by wide intervals, from which other teeth similar to those in place have been detached. The base of each of the above teeth is extended transversely, compressed antero-posteriorly, and anchylosed to a shallow alveolus extending obliquely across the shallower alveolar groove. An affinity to the lizard tribes is manifested by the greater development of the outer as compared with the inner wall of the alveolar furrow.

The palatine teeth, of which there are three or four in each palatal bone, are as large as the superior maxillary ones, and are similarly attached. The pterygoid teeth, five or six in number, which complete the internal dental series on the roof of the mouth, are of smaller size, and gradually diminish as they recede backwards. In the interspaces of the fixed teeth in both these bones, the places of attachment of the shed teeth are always visible, so that the dental formula, if it included the vacated with the occupied sockets, would express a greater number of teeth than are ever in place and use at the same time. In the smaller species of boa, the premaxillary bone is edentulous. All the teeth have a lethal perfection of form for piercing. Their direction prevents the escape of the prey in which they are once fixed; while the separate and independent movement of each half of both upper and lower jaw, and of the dentigerous bones of the palate, allows of the different series of teeth being successively withdrawn and implanted in a more advanced position in the victim, which is thus gradually drawn into the gullet without the retaining force being unduly relaxed during any part of the engulphing process.

The Colubers, like other true serpents, have two longitudinal

[1] *Proceedings of the Geological Society*, Jan. 20, 1841, No. xx., p. 257.

[2] *Geological Transactions*, 2d series, vol. v., p. 345.

Teeth of Reptiles.

rows of teeth on the roof of the mouth, extending along the palatines and pterygoids. The genus *Oligodon* appears to form the sole exception to this rule. In the *Drymus nasutus*, M. Duvernoy has noticed a few small teeth on the transverse bone or external pterygoid, as well as on the internal pterygoid.

In certain genera of non-venomous serpents, as *Dryophis*, *Dipsas*, and *Bucephalus*, in which the superior maxillary teeth increase in size towards the posterior part of the bone, the large terminal teeth of the series are traversed along their anterior and convex side by a longitudinal groove. In the *Bucephalus capensis*, the two or three posterior maxillary teeth present this structure, and are much larger than the anterior teeth, or those of the palatine or premandibular series; they add materially, therefore, to the power of retaining the prey, and may conduct into the wounds which they inflict an acrid saliva, but they are not in connection with the duct of an express poison-gland. The long grooved fangs are either firmly fixed to the maxillary bones, or are slightly moveable, according to their period of growth; they are concealed by a sheath of thick and soft gum, and their points are directed backwards. The sheath always contains loose recumbent grooved teeth, ready to succeed those in place.

In most of the *Colubri* each maxillary and premandibular bone includes from twenty to twenty-five teeth; they are less numerous in the genera *Tortrix* and *Homalopsis*, and are reduced to a still smaller number in the poisonous serpents in the typical genera, of which the short maxillary bone supports only a single perforated fang.

The transition to these serpents, which was begun in the *Bucephali* and allied genera with grooved maxillary teeth, is completed by the poisonous serpents of the genera *Pelamis*, *Hydrophis*, *Elaps*, *Bungarus*, and *Hamadryas*; which latter genus, as its cervical integument can be expanded into a hood, constitutes an intermediate link between *Bungarus* and *Naja*.

The superior maxillary bone (fig. 38, *b*) diminishes in length with the decreasing number of teeth which it supports; the ectopterygoid bone elongates in the same ratio, so as to retain its position as an abutment against the shortened maxillary, and the muscles implanted into this ectopterygoid style communicate, through it, to the maxillary bone, the hinge-like movements backwards and forwards upon the ginglynoid articulations connecting that bone with the anterior frontal and palatal bones. As the fully-developed poison-fangs are attached by the same firm basal anchylosis to shallow maxillary sockets, which forms the characteristic mode of attachment of the simple or solid teeth, they necessarily follow all the movements of the superior maxillary bone. When the external pterygoid is retracted, the superior maxillary rotates backwards, and the poison-fang is concealed in the lax mucous gum with its point turned backwards; when the muscles draw forward the external pterygoid, the superior maxillary bone is pushed forwards, and the recumbent fang withdrawn from its concealment and erected.

Fig. 38.
Skull and Teeth of the Rattlesnake (*Crotalus durissus*).

In this power of changing the direction of a large tooth, so that it may not impede the passage of food through the mouth, we may perceive an analogy between the viper and the Lophius; but in the fish the movement is confined to the tooth alone, and is dependent on the mere physical property of the elastic medium of attachment; in the serpent, the tooth has no independent motion, but rotates with the jaw, whose movements are governed by muscular actions. In the fish, the great teeth are erect, except when pressed down by some extraneous force; in the serpent, the habitual position of the fang is the recumbent one, and its erection takes place only when the envenomed blow is to be struck.

A true idea of the structure of a poison-fang will be formed by supposing the crown of a simple tooth, as that of a boa, to be pressed flat, and its edges to be then bent towards each other, and soldered together so as to form a hollow cylinder open at both ends. The flattening of the fang, and its inflection around the poison-duct, commences immediately above the base, and the suture of the inflected margins runs along the anterior and convex side of the recurved fang: the poison canal is thus in front of the pulp-cavity. The basal aperture of the poison-canal is oblique, and its opposite outlet is more so, presenting the form of a narrow elliptical longitudinal fissure, terminating at a short distance from the apex of the fang.

The character most commonly adduced from the dental system, as distinguishing the venomous from the non-venomous serpents, is, that the former have two, the latter four, rows of teeth in the upper jaw, the two outer or maxillary rows being supplied by the single poison-fang. The exceptions to this rule are, however, too numerous for its value as a distinguishing character in a question of such practical moment as the venomous or non-venomous properties of a serpent. In all the family of marine serpents the poison-fang is only the foremost of a row of fixed maxillary teeth. In the *Hydrophis striatus*, *e.g.*, there are four teeth, and in the *Hydrophis schistosa* there are five teeth behind the venom-fang, of rather smaller size than it; the two-coloured sea-snake (*Pelamys bicolor*) has also five maxillary teeth in addition to the perforated one. The poison-fang in this genus is relatively smaller than in the venomous serpents of the land, but presents the same peculiar structure, and death has followed the wound it has inflicted. The poison-glands occupy the sides of the posterior half of the head: each consists of a number of elongated narrow lobes, extending from the main duct, which runs along the lower border of the gland, upwards and slightly backwards; each lobe gives off lobules throughout its extent, thus presenting a pinnatifid structure; and each lobule is subdivided into smaller secerning cæca, which constitute the ultimate structure of the gland.

Teeth of Reptiles.

The whole gland is surrounded by a double aponeurotic capsule, of which the outermost and strongest layer is in connection with the muscles by whose contraction the several cæca and lobes of the gland are compressed and emptied of their secretion. This is then conveyed by the duct to the basal aperture of the poison-canal of the fang. We may suppose that, as the analogous lacrymal and salivary glands in other animals are most active during particular emotions, so the rage which stimulates the venom-snake to use its deadly weapon must be accompanied with an increased secretion and great distension of the poison-glands; and, as the action of the compressing muscles is contemporaneous with the blow by which the serpent inflicts its wound, the poison is at the same moment injected with force into the wound from the apical outlet of the perforated fang.

The duct which conveys the poison, although it runs through the centre of a great part of the tooth, is really on the outside of the tooth—the canal in which it is lodged and protected being formed by a longitudinal inflection of the parietes of the pulp-cavity, or true internal canal of the tooth. This inflection commences a little beyond the base of the tooth, where its nature is readily appreciated, as the poison-duct there rests in a slight groove or longitudinal indentation on the convex side of the fang; as it proceeds, it sinks deeper into the substance of the tooth, and the sides of the groove meet and seem to coalesce, so that the trace of the inflected fold ceases in some species to be perceptible to the naked eye, and the fang appears, as it is commonly described, to be perforated by the duct in the poison-fang.

From the real nature of the poison-canal it follows, that the transverse section of the tooth varies in form in different parts of the tooth. At the base it is oblong, with a large pulp-cavity of a corresponding form, with an entering notch at the anterior surface; farther on, the transverse section presents the form of a horse-shoe, and the pulp-cavity that of a crescent, the horns of which extend into the sides of the deep cavity of the poison-fang; a little beyond this part the section of the tooth is crescentic, with the horns obtuse and in contact, so as to circumscribe the poison-canal; and along the whole of the middle four-sixths of the tooth, the section shows the dentine of the fang inclosing the poison-cavity, and having its own centre or pulp-cavity *p*, in the form of a crescentic fissure, situated close to the concave border of the inflected surface of the tooth. It is such a section of which a magnified view is given in fig. 39. The pulp-cavity disappears, and the poison-canal again assumes the form of a groove near the apex of the fang, and terminates on the anterior surface in an elongated fissure.

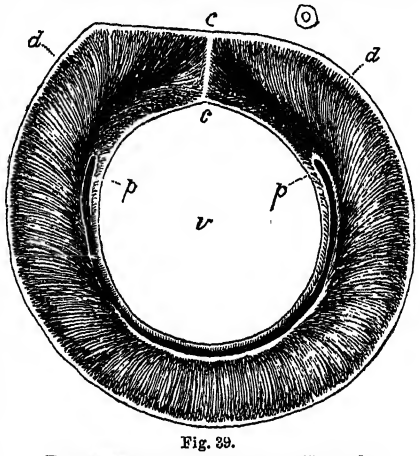

Fig. 39.
Transverse Section of the Poison-Fang of a Rattlesnake.

The venom-fangs of the viper, rattlesnake, and fer-de-lance are coated only with a thin layer of a subtransparent and minutely-cellular cement; the disposition of the calcigerous tubes is obedient to the general law of verticality to the external surface of the tooth: it is represented, as seen in a transverse section from the middle of the fang, in fig. 39. Since the inflected surface of the tooth can be exposed to no other pres-

Teeth of Reptiles.

sure than that of the turgescent duct with which it is in contact, the tubes which proceed to that surface, *v*, while maintaining their usual relation of the right angle to it, are extremely short, and the layer of dentine separating the poison-tube from the pulp-cavity *p* is proportionably thin. The dentinal tubes that radiate from the opposite side of the pulp-cavity to the exposed surface of the tooth *d* are disproportionately long.

The teeth of all Ophidians are developed and completed in that which is the original seat of the tooth-germs in all animals—viz., the mucous membrane or gum covering the alveolar border of the dentigerous bones. This gum presents the same lax tissue, and is as abundantly developed, as in the pike, Lophius, and many other fishes, in which it likewise serves as the nidus and locality for the complete development of the teeth.

The primitive dental papilla in the common harmless snake very soon sinks into the substance of the gum, and becomes inclosed by a capsule. As soon as the deposition of the calcareous salts commences in the apex of the papilla, the capsule covering that part becomes ossified and adherent to the dentine, and the tooth begins to pierce and emerge from the gums before its mould, the pulp, is half completed. Fresh layers of cells are successively added to the base of the pulp, and converted by their confluence and calcification into the tubular dentine, until the full size of the tooth is attained, when its situation in the gum is gradually changed, and its base becomes anchylosed to the shallow cavity of the alveolar surface of the bone.

In the posterior part of the large mucous sheath of the poison-fang, the successors of this tooth are always to be found in different stages of development: the pulp is at first a simple papilla, and when it has sunk into the gum, the succeeding portion presents a depression along its inferior surface, as it lies horizontally with the apex directed backwards. The capsule adheres to this inflected surface of the pulp; and the introduction of the duct of the poison-gland is completed by the extension of the borders of the inflected pulp around that tube.

Lacertia.

Among the inferior or squamate Saurians (lizards, monitors, iguanas) there are two leading modifications in the mode of attachment of the teeth, the base of which may be either anchylosed to the summit of an alveolar ridge, or to the bottom of an alveolar groove, and supported by its lateral wall; these modifications are indicated by the terms "acrodont" and "pleurodont." A third mode of fixation is presented by some extinct Saurians, which in other parts of their organization adhere to the squamate or lacertine division of the order,—the teeth being implanted in sockets, either loosely or confluent with the bony walls of the cavity: these may be termed the "thecodont"[1] Lacertians. Most of the ancient triassic and permian Saurians belong to this group.

Varanidæ.

In the crocodilian monitor-lizard (*Varanus crocodilinus*), the large fixed compressed teeth, of which there may be about seven in each upper maxillary bone, and six in each premandibular, are anchylosed by the whole of their base, and by an oblique surface leading upwards on the outer side of the tooth to a slight depression on the oblique alveolar surface, as in the variety called *striatus*. In this monitor the base of the tooth is finely striated, the lines being produced by inflected folds of the external cement, as in the Ichthyosaur and Labyrinthodon, but being short and straight, as in those of the former genus.

The alveolar channel or groove has scarcely any depth; but the anchylosed base of the tooth is applied to an oblique surface, terminating in a sharp edge, from which the outer side of the free crown of the tooth is directly continued. The great *Varanus*, like the variegated species, manifests its affinity to the Crocodilians in the number of successive teeth which are in progress of growth to replace each other; but from the position in which the germs of the successional teeth are developed, the more advanced teeth in this species, as in the variety *variegatus*, do not exhibit the excavation that characterizes the same parts of the teeth of the Enaliosaurs and crocodile.

Dinosauria.

The compressed piercing and trenchant form of tooth which characterizes the varanian lizards was anciently manifested by a gigantic extinct Saurian, of which the remains were discovered by the late Dr Buckland in the oolitic slate of Stonesfield, near Oxford. These remains have been examined by the writer in the geological museum of that university. The specimen which is most illustrative of the dental peculiarities is a portion of the lower jaw with a few teeth. The first character which attracts the attention of the anatomist in this fossil is the inequality in the height of the outer and inner alveolar walls. This assures him of the saurian affinities of the gigantic reptile, a similar inequality characterizing the jaws of almost all the existing lizards. But in these the oblique groove, so bounded, to which the bases of the developed teeth are anchylosed, is much more shallow, and is relatively wider; and the teeth in all the stages of growth are completely exposed when the gum has been removed.

Teeth of Reptiles.

In the great oolitic carnivorous lizard, which its discoverer has called *Megalosaurus*, the greater relative development of the inner alveolar wall, as compared with the dentigerous part of the jaw in existing Saurians, narrows the dental groove, and covers a greater proportion of the bases of the teeth, besides concealing more or less completely the germs of their successors. Moreover, instead of the mere shallow impressions upon the inner side of the outer alveolar plate to which the teeth are attached in modern lizards, there are distinct sockets formed by bony partitions connecting the outer with the inner alveolar wall in the jaw of the Megalosaurus. These partitions rise from the outer side of the inner alveolar wall in the form of triangular vertical plates of bone, and from the middle of the outer side of each plate a bony partition crosses to the outer parapet, completing the alveoli of the fully-formed or more advanced teeth; the series of triangular plates forming a kind of zig-zag buttress along the inner side of those alveoli. The outer parapet rises an inch higher than the inner one.

Megalosaurus.

Of the fully-developed teeth, only one has been preserved *in situ* in the specimen under description; the others appear rather to have slipped out than to have been broken off, the anchyloses of the basal capsule of the tooth to the alveolar periosteum being but slight, and apparently taking place tardily, in the Megalosaurus.

Fig. 40 exhibits a portion of another jaw of the *Megalosaurus*, also

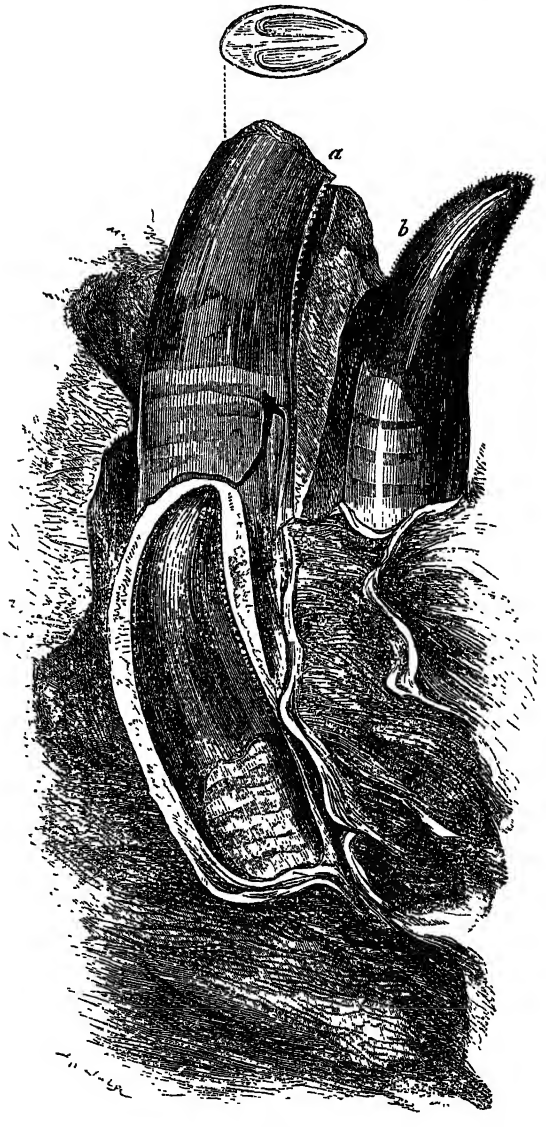

Fig. 40.
Section of Jaw with Teeth of the *Megalosaurus Bucklandi*, nat. size.

from Stonesfield oolite, from which the inner wall has been removed

[1] Θηκη, *a sheath*; ὀδους, *a tooth*.

Teeth of Reptiles.

to show the germ of a successional tooth *c*, about to succeed an old tooth *a*, which has been broken, and near to which is a newly-formed tooth coming into place *b*. These teeth well exemplify the shape of the crown of the tooth, which is subcompressed, slightly recurved, sharp-edged, and sharp-pointed, the edges being minutely serrated; the edge upon the convex or front border *b* becomes blunted as it descends about two-thirds of the way towards the base of the tooth; that upon the concave hinder border *a* is continued to the base. The lower half of the crown is thicker towards the fore margin than towards the hind one; so that a transverse section, like that above (*a*, in fig. 40), gives a narrow oval form pointed behind. At the upper half of the crown the sides slope more equally from the middle thickest part to both margins, and the section is a narrow pointed ellipse. The crown is covered by a smooth and polished enamel, which wholly forms the marginal serrations. The base of the tooth is coated with a smooth, lighter-coloured cement, forming a thin layer, and becoming a little thicker towards the implanted end of the tooth. The remains of the pulp are converted into osteo-dentine in the basal part of the completely formed tooth. Moderately magnified, the surface of the enamel presents a finely-wrinkled appearance. The marginal serrations show, under a somewhat higher power, that the points are directed towards the apex of the tooth—a structure well adapted for dividing the tough tissues of the saurian integument.

The main body of the tooth consists of dentine, of that hard unvascular kind of which the same part of the teeth of existing crocodiles and most mammals is composed. The dentinal tubules in the Megalosaurus are extremely fine and close-set, presenting a diameter of $\frac{1}{25000}$th of an inch, with interspaces varying between two and three times that diameter. They radiate from the pulp-cavity at right angles with the external surface of the tooth. The primary curvatures correspond with those of the dentinal tubules in the Varanus (figured in the author's *Odontography*, plate lxvii., fig. 2), but they are less marked; so that the tubules appear straighter in the Megalosaurus. After their origin, they dichotomize sparingly, but the number of minute secondary branches sent off into the intermediate substance is very great. These secondary branches proceed at acute angles from the primary tubules; the divisions of the latter become very frequent near the periphery of the dentine, and the terminal branches dilate into, or inosculate with, a stratum of minute calcigerous cells, which separates the dentine from the enamel.[1] No part of the dentine is pervaded by medullary canals, as in the Iguanodon.

A series of teeth from individual Megalosauri, of different ages, are preserved in the British Museum and in the geological museum at Oxford; although differing in size, they preserve the characteristic form above described. In one specimen the point of the crown and the trenchant margins have been rubbed down to a smooth obtuse surface; it seems to have come from the hinder part of the dental series, where the teeth may have been smaller and less sharp, or more liable to be blunted by a greater share in the imperfect act of mastication, than the teeth in advance.

Successional teeth in different stages of growth are shown in the original portion of jaw of the Megalosaurus in the Oxford museum. Some, more advanced, show their crowns projecting from alveoli already formed by the plates extending across from the triangular processes before described. Vacant sockets, from which fully-formed teeth have escaped, occur, generally in the intervals between these more advanced teeth. The summits of less developed teeth are seen protruding at the inner side of the basal interspaces of the triangular plate, between them and the true internal alveolar parapet. There can be no doubt that, in the course of the development of these teeth, corresponding changes take place in the jaw itself, by which new triangular plates and alveolar partitions are formed, as the old ones become absorbed, analogous to those concomitant changes in the growth and form of the teeth, alveoli, and jaws which take place in so striking a degree in the elephant. The peculiarity of the Megalosaurus, as compared with the crocodiles and lizards, which have a like endless succession of teeth, is the deeper position of the successional tooth (fig. 40, c), in relation to the one (*a*) it is destined to replace, and the great proportion of the tooth which is formed before it is protruded. This interesting character is well exhibited in the portion of the jaw kindly submitted to the author's examination by the late Duke of Marlborough, and a portion of which is shown in fig. 40. The anterior tooth *a* in this specimen shows at the inner side of its base the commencing absorption stimulated by the encroaching capsule of the successional tooth *c* below, the crown of which is completed externally, though not consolidated. On one of the fractured margins of this piece of jaw, a part of the basal shell of an absorbed and shed tooth remains, with part of the root of the successional tooth, which has risen into place, but which shows its base full of matrix, the pulp not having been calcified at that period of the tooth's growth.

Teeth of Reptiles.

In the proportion of the successional teeth which is formed in the formative cavity in the substance of the jaw, the Megalosaurus offers a closer resemblance to the mammalian class than do any of the recent or extinct crocodilian or lacertian reptiles. But the evidence of uninterrupted and frequent succession of the teeth in the Megalosaurus is unequivocal; and this part of the dental economy of the great carnivorous reptile is strictly analogous to that which governs the same system in the existing members of the class. The different forms of the teeth at different stages of protrusion did not fail to attract the attention of the gifted discoverer of the Megalosaurus, in whose words this notice of its dentition may be fitly concluded:—

"In the structure of these teeth we find a combination of mechanical contrivances analogous to those which are adopted in the construction of the knife, the sabre, and the saw. When first protruded above the gum, the apex of each tooth presented a double cutting edge of serrated enamel. In this stage its position and line of action were nearly vertical; and its form, like that of the two-edged point of a sabre, cutting equally on each side. As the tooth advanced in growth, it became curved backwards in the form of a pruning-knife, and the edge of serrated enamel was continued downwards to the base of the inner and cutting side of the tooth, whilst on the outer side a similar edge descended, but a short distance from the point; and the convex portion of the tooth became blunt and thick, as the back of a knife is made thick for the purpose of producing strength. The strength of the tooth was further increased by the expansion of its side. Had the serrature continued along the whole of the blunt and convex portion of the tooth, it would in this position have possessed no useful cutting power; it ceased precisely at the point beyond which it could no longer be effective. In a tooth thus formed for cutting along its concave edge, each movement of the jaw combined the power of the knife and saw; whilst the apex, in making the first incision, acted like the two-edged point of a sabre. The backward curvature of the full-grown teeth enabled them to retain, like barbs, the prey which they had penetrated, In these adaptations we see contrivances which human ingenuity has also adopted in the preparation of various instruments of art."[2]

Iguanidæ.

The lizards of the Iguanian family are characterized by a short contractile tongue, slightly notched at its extremity, but are distinguished for the most part by having teeth on the pterygoid bone, and also by the complicated form of the crown of the maxillary teeth in the typical genera, the species of which subsist chiefly on vegetable substances. In most of the Iguanians the teeth are lodged in a common shallow, oblique, alveolar groove, and are soldered to excavations on the inner surface of the outer wall of the groove.

In the pleurodont Iguanians, the teeth never present the true laniary form; and if simply conical, as at the extremes of the maxillary series, the cone is more or less obtuse; but in general it is expanded, more or less trilobate, or dentated along the margins of the crown.

The dentition of the Basilisks differs little from that of the Iguanæ. The posterior teeth are rather trilobate than tricuspid; the anterior ones are small, circular, pointed, and slightly curved. There are generally from five to six conical teeth on each pterygoid bone; but in the mitred Basilisk there are twelve teeth in each of these rows.

The *Amblyrhynchus*, a genus which is somewhat remarkable for the marine habits of at least one of the species (*Amblyrhynchus ater*), whose diet is sea-weed, has the tricuspid structure well developed in the posterior teeth.

The typical genus of the present family of Saurians is characterized by the crenate or dental margin of the crown of the maxillary and premandibular teeth, a few of the anterior small ones excepted. The pterygoid teeth are arranged in two or three irregular rows, resembling somewhat the *dents en cardes* of fishes.

In the full-grown horned Iguana (*Metopoceros cornutus*, Dum.), there are about fifty-six teeth in both the upper and lower jaws, of which the four first are conical and slightly recurved; the twelve succeeding teeth are somewhat larger in size, with more compressed and expanded crowns; the rest are triangular, compressed, with dentated margins. The inner surface of the crown of the tooth is simply convex and smooth, the outer surface traversed by a median longitudinal, broad, obtuse ridge. Fig. 41 gives a view of these teeth on the inner side of the lower jaw: *a*, the teeth in place, anchylosed to the outer parapet of the alveolar groove; *b*, the germ

[1] The microscopic characters of the tooth of the Megalosaurus are represented in the *Odontography*, pl. lxx. A, in part of a transverse section of the middle of the crown, including the pulp-cavity and its osteo-dentine.

[2] Buckland, *Bridgewater Treatise*, vol. i., p. 237.

Teeth of Reptiles.

of a successional tooth; *c*, a tooth more advanced, and rising into place. The base of the older teeth soon begins to be sapped by the absorbent process excited by the pressure of the capsules of their

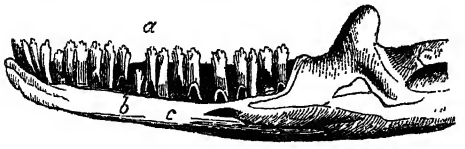

Fig. 41.
Lower Jaw and Teeth of an Iguana (*Metopoceros cornutus*).

successors. In the common as in the horned iguana there is a single row of small teeth implanted in each pterygoid bone; but no iguanian lizard has teeth on the palatine bones.

The pulp-cavity in old teeth becomes occupied by a coarse bone, characterized by large irregularly-shaped calciferous cells; and the interspaces are filled with irregular moss-like reticulations of tubes. Branches of the pulp-cavity are never continued in the form of medullary canals into the substance of the dentine in the existing Iguanæ.

The germs of the successional teeth (*b*, fig. 41), are developed from the mucous membrane covering the inner side of the base of those in place. The apex of the dentated crown is first formed; by its pressure it excites absorption of the base of the fixed tooth, and soon undermines it, and then occupies the recess in the alveolar plate in the interspace of the two adjoining fixed teeth. After the crown is completed, the rest of the tooth forms a contracted and elongated fang, which at first is hollow, then becomes consolidated by ossification of the remaining pulp *c*, and is afterwards a second time excavated by the pressure of a new tooth.

Dinosauria. Iguanodon.

The value of a knowledge of the comparative anatomy of the teeth, and especially of their external characters, in the cold-blooded classes of animals, has never, perhaps, been placed in so striking a point of view as in the leading steps to the discovery of the present most extraordinary and gigantic reptile. The detached teeth and bones of the *Iguanodon*, successively discovered in the Wealden strata of Sussex, and afterwards found associated together to the extent of nearly half the skeleton of one and the same individual, in the greensand of Kent, offer not the least marvellous or significant evidences of the inhabitants of the now temperate latitudes during the later secondary periods of the formation of the earth's crust.

With vertebræ, subconcave at both articular extremeties, having, in the dorsal region, lofty and expanded neural arches, and doubly articulated ribs, and characterized in the sacral region by their unusual number and complication of structure; with a Lacertian pectoral arch, and unusually large bones of the hind limbs, excavated by large medullary cavities, and adapted for terrestrial progression;—the *Iguanodon* was distinguished by teeth, resembling in shape those of the Iguana, but in structure differing from the teeth of that and every other known reptile, and unequivocally indicating the former existence in the Dinosaurian order of a gigantic representative of the small group of living lizards which subsist on vegetable substances.

The important difference which the fossil teeth presented in the form of their grinding surface was pointed out by Cuvier,[1] of whose description Dr Mantell adopted a condensed view in his *Illustrations of the Geology of Sussex*, 4to, 1827, p. 72. The combination of this dental distinction with the vertebral and costal characters, which prove the *Iguanodon* not to have belonged to the same group of Saurians as that which includes the Iguana and other modern lizards, rendered it highly desirable to ascertain by the improved modes of investigating dental structure, the actual amount of correspondence between the *Iguanodon* and Iguana in this respect. This has been done in the author's general description of the *teeth of reptiles*,[2] from which the following notice is abridged:—

The teeth of the *Iguanodon* (fig. 42), though resembling most closely those of the Iguana, do not present an exact magnified image of them, but differ in the greater relative thickness of the crown, its more complicated external surface, and, still more essentially, in a modification of the internal structure, by which the *Iguanodon* equally deviates from every other known reptile.

As in the Iguana, the base of the tooth is elongated and contracted; the crown expanded and smoothly convex on the inner side; when first formed it is acuminated, compressed, its sloping sides serrated, and its external surface traversed by a median longitudinal ridge, and coated by a layer of enamel; but beyond this point the description of the tooth of the *Iguanodon* indicates characters peculiar to that genus. In most of the teeth that have hitherto been found, three longitudinal ridges traverse the outer surface of the crown, one on each side of the median primitive

Teeth of Reptiles.

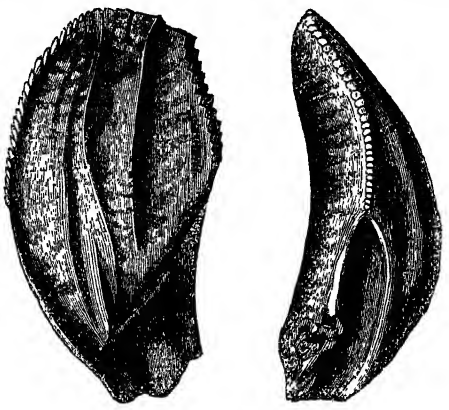

Fig. 42.
Front and side views of a Tooth of the Iguanodon, nat. size.

ridge; these are separated from each other and from the serrated margins of the crown by four wide and smooth longitudinal grooves. The relative width of these grooves varies in different teeth; sometimes a fourth small longitudinal ridge is developed on the outer side of the crown. The marginal serrations which, at first sight, appear to be simple notches, as in the Iguana, present under a low magnifying power (fig. 43), the form of transverse ridges, themselves notched, so as to resemble the mammilated margins of the unworn plates of the elephant's grinder; slight grooves lead from the interspaces of these notches upon the sides of the marginal ridges. These ridges or dentations do not extend beyond the expanded part of the crown; the longitudinal ridges are continued farther down, especially the median ones, which do not subside till the fang of the tooth begins to assume its subcylindrical form. The tooth at first increases both in breadth and thickness; then it diminishes in breadth, but its thickness goes on increasing; in the larger and fully formed teeth, the fang decreases in every diameter, and sometimes tapers almost to a point. The smooth unbroken surface of such fangs indicates that they did not adhere to the inner side of the maxillæ, as in the Iguana, but were placed in separate alveoli, as in the Crocodile and Megalosaur; such support would appear, indeed, to be indispensable to teeth so worn by mastication as those of the *Iguanodon*.

Fig. 43.
Marginal ridges on the Tooth of the Iguanodon, magn.

The apex of the tooth soon begins to be worn away, and it would appear, by many specimens, that the teeth were retained until nearly the whole of the crown had yielded to the daily abrasion. In these teeth, however, the deep excavation of the remaining fang plainly bespeaks the progress of the successional tooth prepared to supply the place of the worn-out grinder. At the earlier stages of abrasion a sharp edge is maintained at the external part of the tooth by means of the enamel which covers that surface of the crown; the prominent ridges upon that surface give a sinuous contour to the middle of the cutting edge, whilst its sides are jagged by the lateral serrations. The adaptation of this admirable dental instrument to the cropping and comminution of such tough vegetable food as the *Clathrariæ* and similar plants, which are found buried with the *Iguanodon*, is pointed out by Dr Buckland, with his usual felicity of illustration, in his *Bridgewater Treatise*, vol. i., p. 246.

When the crown is worn away beyond the enamel, it presents a broad and nearly horizontal grinding surface (fig. 44), and now another dental substance is brought into use, to give an inequality to that surface; this is the ossified remnant of the pulp, which, being firmer than the surrounding dentine, forms a slight transverse ridge in the middle of the grinding surface: the tooth in this stage has exchanged the functions of an incisor for that of a molar, and is prepared to give the final compression, or comminution, to the coarsely divided vegetable matters.

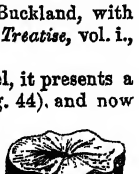

Fig. 44.
A worn Tooth of the Iguanodon.

The marginal edge of the incisive condition of the tooth and the median ridge of the molar stage are more effectually established by the introduc-

[1] *Ossemens Fossiles*, 1824, vol. v., pt. ii., p. 351.

[2] *Odontography*, pt. ii., p. 249; *Transactions of the British Association*, 1838.

Teeth of Reptiles.

tion of a modification into the texture of the dentine, by which it is rendered softer than in the existing Iguanæ and other reptiles, and more easily worn away. This is effected by an arrest of the calcifying process along certain cylindrical tracts of the pulp, which is thus continued, in the form of medullary canals, analogous to those in the soft dentine of the Megatherium's grinder, from the central cavity, at pretty regular intervals, parallel with the dentinal tubes, nearly to the surface of the tooth. The medullary canals radiate from the internal and lateral sides of the pulp-cavity, and are confined to the dentine forming the corresponding walls of the tooth. Their diameter is $\frac{1}{1250}$th of an inch. They are separated by pretty regular intervals equal to from six to eight of their own diameters. They sometimes divide once in their course. Each medullary canal is surrounded by a clear space. Its cavity was occupied in the section described by a substance of a deeper yellow colour than the rest of the dentine.

The dentinal tubes present a diameter of $\frac{1}{25,000}$th of an inch, with interspaces equal to about four of their diameters. At the first part of their course, near the pulp-cavity, they are bent in strong undulations, but afterwards proceed in slight and regular primary curves, or in nearly straight lines to the periphery of the tooth. The secondary undulations of each tooth are regular, and very minute. The branches, both primary and secondary, of the dentinal tubes are sent off from the concave side of the main inflections; the minute secondary branches are remarkable at certain parts of the tooth for their flexuous ramifications, anastomoses, and dilatations into minute calcigerous cells, which take place along nearly parallel lines for a limited extent of the course of the main tubes. The appearance of interruption in the course of the dentinal tubes, occasioned by this modification of their secondary branches, is represented by the irregularly dotted tracts in the figure. This modification must contribute, with the medullary canals, though in a minor degree, in producing that inequality of texture and of density in the dentine, which renders the broad and thick tooth of the *Iguanodon* more efficient as a triturating instrument.

The enamel which invests the harder dentine, forming the outer side of the tooth, presents the same peculiar dirty brown colour, when viewed by transmitted light, as in most other teeth. Very minute and scarcely perceptible undulating fibres, running vertically to the surface of the tooth, form the only discernible structure in it.

The remains of the pulp in the contracted cavity of the completely formed tooth are converted into a dense but true osseous substance, characterized by minute elliptical radiated cells, whose long axis is parallel with the plane of the concentric lamellæ, which surround the few and contracted medullary canals in this substance.

The microscopical examination of the structure of the *Iguanodon's* teeth thus contributes additional evidence of the perfection of their adaptation to the offices to which their more obvious characters had indicated them to have been destined.

To preserve a trenchant edge, a partial coating of enamel is applied; and, that the thick body of the tooth might be worn away in a more regularly oblique plane, the dentine is rendered softer as it recedes from the enamelled edge, by the simple contrivance of arresting the calcifying process along certain tracts of the inner wall of the tooth. When attrition has at length exhausted the enamel, and the tooth is limited to its function as a grinder, a third substance has been prepared in the ossified remnant of the pulp to add to the efficiency of the dental instrument in its final capacity. And if the following reflections were natural and just, after a review of the external characters of the dental organs of the *Iguanodon*, their truth and beauty become still more manifest as our knowledge of their subject becomes more particular and exact:—

"In this curious piece of animal mechanism we find a varied adjustment of all parts and proportions of the tooth, to the exercise of peculiar functions, attended by compensations adapted to shifting conditions of the instrument during different stages of its consumption. And we must estimate the works of nature by a different standard from that which we apply to the productions of human art, if we can view such examples of mechanical contrivance, united with so much economy of expenditure, and with such anticipated adaptations to varying conditions in their application, without feeling a profound conviction that all this adjustment has resulted from design and high intelligence."[1]

Dicynodon.

The existing species of lizard differ from those of the crocodile in the anchylosed condition of the teeth, which present few modifications of importance; those that yield most fruit to physiology, and which have most expanded our ideas of the extent of the resources and exceptional deviations from what was deemed the rule of structure in the Saurian dentition, have been discovered by the study of the fossil teeth of extinct forms of the order. Amongst these the most extraordinary, in respect of their dental system, have been recently discovered in a probably "Permian" formation in South Africa. These fossil reptiles have been termed "Dicynodonts," from their dentition being reduced to one long and large canine tooth on each side of the upper jaw, and these teeth impart, at first sight, a character to the jaws like that which the long poison-fangs give, when erected, to the jaws of the rattlesnake. Fig. 45 is a reduced side view of the skull and teeth of the

Teeth of Reptiles.

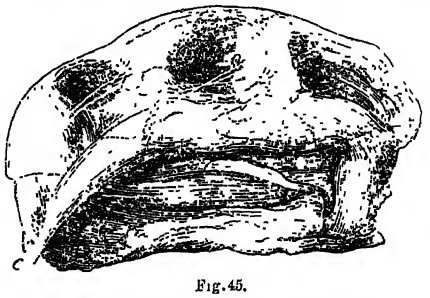

Fig. 45.

Skull and Tusks of *Dicynodon lacerticeps*.

Dicynodon lacerticeps. The maxillary bone is excavated by a wide and deep alveolus, with a circular area of half an inch, and lodges a long and strong, slightly curved, and sharp-pointed canine tooth or tusk *c*, which projects about two-thirds of its length from the open extremity of the socket. The direction of the tusks is forwards, downwards, and very slightly inwards; the two converging in the descent along the outer side of the compressed symphysis of the lower jaw. The tusk is principally composed of a body of compact unvascular dentine. The base is excavated by a wide conical pulp-cavity, with the apex extending to about one-half of the implanted part of the tusk, and a linear continuation extending along the centre of the solid part of the tusk. From this central line the dentinal tubes radiate, with a gentle curve at the beginning, convex towards the point of the tusk, and then proceeding straight to the periphery of the tooth, but inclining towards the apex. They present parallel secondary curves, divide dichotomously twice or thrice near their beginning, and send off numerous small lateral branches, chiefly from the side next the apex. At their primary curve the dentinal tubes are $\frac{1}{12000}$th of an inch in diameter, and their intervals are $\frac{1}{10000}$th of an inch across. The dentinal cells are most conspicuous near the periphery of the tooth, and vary in diameter from $\frac{1}{8000}$th to $\frac{1}{10000}$th of an inch.

The enamel, at least at the middle of the tusk, is thinner than in the teeth of the crocodile. It presents only a finely lamellated texture, the layers being parallel with the surface of the dentine on which it rests. There is only a fine linear trace of cement on the exterior of the sections of the implanted base of the tusks; and here it is too thin to allow of the development of the radiated cells in its substance. There is no trace of teeth or their sockets in the lower jaw,[2] so much of the alveolar border as is exposed presents a smooth and even edge, which seems to have played like a scissor-blade upon the inner side of the corresponding edentulous border of the upper jaw; and it is most probable, from the analogies of similarly-shaped jaws of existing reptilia, that the fore-part of both the upper and under jaws were sheathed with horn.

Until the discovery of the Rhynchosaurus, this edentulous and horn-sheathed condition of the jaws was supposed to be peculiar to the chelonian order among reptiles; and it is not one of the least interesting features of the Dicynodonts of the African sandstones, that they should repeat a chelonian character hitherto peculiar amongst Lacertians, to the above-cited remarkable extinct edentulous genus of the new red sandstone of Shropshire; but our interest rises almost to astonishment, when, in a saurian skull, we find, superadded to the horn-clad mandibles of the tortoise, a pair of tusks, borrowed, as it were, from the mammalian class, or rather foreshadowing a structure which, in the existing creation, is peculiar to certain members of the highest organized warm-blooded animals.

Crocodilia.

Crocodilia.—The ancient writers on natural history appear to have been much struck with the great number of teeth in the crocodile; and their descriptions were exaggerated to the tone of the impressions thus produced. Thus, according to Achilles Tatius, the crocodile had as many teeth as there were days in the year.

How many teeth a crocodile may develop through the whole course of its life in uninterrupted succession, will never, perhaps, be determined; they then would doubtless far exceed in number the liberal allowance of Tatius; but with regard to those teeth which are in use in the jaws at any given time, the number is now

[1] Buckland's *Bridgewater Treatise*, vol. i., p. 249.

[2] δις, two, κυνόδους, canine tooth.

Teeth of Reptiles.

well established—*e.g.*, the crocodile of the Nile has $\frac{17—17}{16—16}=66$; that of the West Indies (*Crocodilus acutus*) has $\frac{17—17}{16—16}=66$; the common aligator (*Aligator lucius*), has $\frac{20—20}{18—18}=76$. The great gavial or garrhial (*Gavalis Gangeticus*) has $\frac{30—30}{20—20}=778$. Thus the different species and genera of crocodiles differ from each other in the number of teeth, and also the individuals differ within small limits.

The best and most readily recognisable characters by which the existing Crocodilians are grouped in appropriate genera are derived from modifications of the dental system.

In the caimans (genus *Alligator*) the teeth vary in number from $\frac{18—18}{18—18}$ to $\frac{22—22}{22—22}$; the fourth tooth of the lower jaw or canine, is *received into a cavity* of the palatal surface of the upper jaw, where it is concealed when the mouth is shut; in old individuals the upper jaw is perforated by these large inferior canines, and the fossæ are converted into foramina.

In the true crocodiles (genus *Crocodilus*) the first tooth in the lower jaw perforates the palatal process of the intermaxillary bone when the mouth is closed; the fourth tooth in the lower jaw is *received into a notch* excavated in the side of the alveolar border of the upper jaw, and is visible externally when the mouth is closed.

In the two preceding genera the alveolar borders of the jaws have an uneven or wavy contour, and the teeth are of unequal size.

In the gavials (genus *Gavialis*) the teeth are nearly equal in size and similar in form in both jaws, and the first as well as the fourth tooth in the lower jaw passes into a groove in the margin of the upper jaw, when the mouth is closed.

The number of teeth is always greater in the gavials than in the crocodiles or alligators. The first five pairs of teeth above are supported by the premaxillary bones; the first, second, and fourth of the lower jaw are the longest.

The eight or nine posterior teeth are nearly conical, the rest are sub-compressed antero-posteriorly, and present a trenchant edge on the right and left side, between which a few faint longitudinal ridges traverse the basal part of the enamelled crown (fig. 46).

Fig. 46.
Teeth of the Gavial.

The position of the opposite sharp ridges, and the direction of the flat sides of the crown, are reversed in the extinct crocodile (*Croc. cultridens*), which in other respects most nearly resembles the gavial in the form of the teeth.

In most of the extinct species of Crocodilians the teeth are characterized by more numerous and strongly developed longitudinal ridges upon the enamelled crown, than in the recent species; and they are commonly longer, more slender, and sharp-pointed. But in one of the crocodiles with sub-biconcave vertebræ (*Goniopholis crassidens*), from the Wealden formation and Purbeck limestone, the teeth have crowns which are as round and as thick in proportion to their length as in the recent crocodiles or alligators.

The more ancient crocodiles, from the Oolite and Lias, called *Steneosauri* and *Teleosauri*, had jaws like those of the modern gavials, but sometimes longer and more attenuated, and armed with more numerous, equal, and slender teeth, adapted for the capture of fishes, which appear to have been the only other vertebrate animals existing at those periods in numbers sufficient to yield subsistence to carnivorous marine Saurians.

In all the *Teleosauri* the teeth are more slender, less compressed, and sharper pointed than in the gavial; they are slightly recurved, and the enamelled crown is traversed by more numerous and better defined ridges—two of which, on opposite sides of the crown, are larger and more elevated than the rest. The fang is smooth, cylindrical, and always excavated at the base. The teeth of the *Steneosauri*, or extinct crocodiles with long and slender jaws, and with vertebræ sub-concave at both extremities, but with subterminal nostrils, differ from those of the *Teleosauri* in being somewhat thicker in proportion to their length, and larger in proportion to the jaws.

The teeth of both the existing and extinct crocodilian reptiles consist of a body of compact dentine, forming a crown covered by a coat of enamel, and a root invested by a moderately thick layer of cement. The root slightly enlarges or maintains the same breadth to its base (fig. 46, *a*), which is deeply excavated by a conical pulp-cavity extending into the crown, and is commonly either perforated or notched at its concave or inner side.

In the black alligator of Guiana, the first fourteen teeth in the lower jaw are implanted in distinct sockets. The remaining posterior teeth are lodged close together in a continuous groove, in which the divisions for sockets are faintly indicated by vertical ridges, as in the jaws of the Ichthyosaurus.

Teeth of Reptiles.

A thin compact floor of bone separates this groove and the sockets anterior to it (fig. 47) from the large cavity of the ramus of the jaw. It is pierced by blood-vessels for the supply of the pulps of the growing teeth and the vascular dentigerous membrane which lines the alveolar cavities.

Fig. 47.
Section of Jaw with Teeth of the Alligator.

The tooth-germ *c* (fig. 47) is developed from the membrane covering the angle between the floor and the inner wall of the socket. It becomes, in this situation, completely enveloped by its capsule, and partially calcified, before the young tooth penetrates the interior of the pulp-cavity of its predecessor.

The matrix of the young growing tooth affects, by its pressure, the inner wall of the socket, as shown in fig. 47, and forms for itself a shallow recess, at the same time it attacks the side of the base of the contained tooth; then, gaining a more extensive attachment by its basis and increased size, it penetrates the large pulp-cavity of the previously formed tooth either by a circular or semicircular perforation. The size of the perforation in the tooth, and of the depression in the jaw, proves them to have been in great part caused by the soft matrix, which must have produced its effect by exciting absorbent action, and not by mere mechanical force. The resistance of the wall of the pulp-cavity having been thus overcome, the growing tooth and its matrix recede from the temporary alveolar depression, and sink into the substance of the pulp contained in the cavity of the fully-formed tooth.

As the new tooth grows, the pulp of the old one is removed; the old tooth itself is next attached, and the crown, being undermined by the absorption of the inner surface of its base, may be broken off by a slight external force, when the point of the new tooth is exposed, as in figs. 46 and 47, *b*.

The new tooth disembarrasses itself of the cylindrical base of its predecessor (fig. 47, *a*) with which it is sheathed, by maintaining the excitement of the absorbent process so long as the cement of the old fang retains any vital connection with the periosteum of the socket; but the frail remains of the old cylinder, thus reduced, are sometimes lifted out of the socket upon the crown of the new tooth (as in fig. 46, *a*), when they are speedily removed by the action of the jaws. This is, however, the only part of the process which is immediately produced by violence; an attentive observation of the more important previous stages of growth, teaches that the pressure of the growing tooth operates upon the one to be displaced only through the medium of the vital absorbent action which it has excited.

Most of the stages in the development and succession of the teeth of the crocodiles are described by Cuvier with his wonted clearness and accuracy; but the mechanical explanation of the expulsion of the old teeth, which Cuvier adopts from M. Tenon, is opposed by the disproportion of the hard part of the new tooth to the vacuity in the walls of the old one, and by the fact that the matter impressing, viz., the uncalcified part of the tooth matrix, is less dense than the part impressed.

No sooner has the young tooth (fig. 46, *b*) penetrated the interior of the old one (fig. 46, *a*) than another germ *c*, begins to be developed from the angle between the base of the young tooth and the inner alveolar process; or in the same relative position as that in which its predecessor began to rise, and the processes of succession and displacement are carried on uninterruptedly throughout the long life of these cold-blooded carnivorous reptiles.

From the period of exclusion from the egg, the teeth of the crocodile succeed each other in the vertical direction; none are added from behind forwards like the true molars in Mammalia. It follows, therefore, that the number of the teeth of the crocodile is as great when it first sees the light as when it has acquired its full size; and, owing to the rapidity of their succession, the cavity at the base of the fully-formed tooth is never consolidated.

The fossil jaws of the extinct Crocodilians demonstrate that the same law regulated the succession of the teeth at the ancient epochs when those highly-organised reptiles prevailed in greatest numbers, and under the most varied generic and specific modifications, as at the present period, when they are reduced to a single family composed of so few and slightly varied species as to have constituted in the system of Linnæus a small fraction of the genus *Lacerta*.

Teeth of Mammals.

Sect. III.—TEETH OF MAMMALS.

Number.

The class *Mammalia*, like that of *Reptilia* and *Pisces*, includes a few genera and species that are devoid of teeth; the true ant-eaters (*Myrmecophaga*), the scaly ant-eaters, or Pangolins (*Manis*), and the spiny monotrematous ant-eater (*Echidna*), are examples of strictly edentulous Mammals. The *Ornithorhynchus* has horny teeth, and the whales (*Balæna* and *Balænoptera*) have transitory embryonic calcified teeth (fig. 59), succeeded by whale-bone substitutes (fig. 58), in the upper jaw. Horny processes analogous to, perhaps homologous with, the lingual and palatal teeth in fishes, are present in the *Echidna*. The female Narwhal seems to be edentulous, but has the germs of two tusks in the substance of the upper jaw-bones (fig. 62); one of these becomes developed into a large and conspicuous weapon in the male Narwhal (fig. 62, a), and accordingly suggested to Linnæus the name, for its genus, of *Monodon*, meaning single tooth. But the tusk is never median, like the truly single tooth on the palate of the Myxine; and occasionally both tusks are developed in the Narwhal. In another Cetacean—the great Bottle-nose or *Hyperoodon*—the teeth are reduced in the adult to two in number (fig. 61), whence the specific name, *H. bidens;* but they are confined to the lower jaw. The sharp-nosed dolphin (*Ziphius*) has also but two teeth, one in each ramus of the lower jaw; and this is perhaps a sexual character.

The *Delphinus griseus* has five teeth on each side of the lower jaw; but they soon become reduced to two. Amongst the Marsupial animals, the genus *Tarsipes* is remarkable for the paucity as well as minuteness of its teeth. The Elephant has never more than one entire molar, or parts of two, in use on each side of the upper and lower jaws, to which are added two tusks, more or less developed, in the upper jaw.

Some Rodents, as the Australian water-rats (*Hydromys*), have two grinders on each side of both jaws, which, added to the four cutting teeth in front, make twelve in all; the common number of teeth in this order is twenty; but the hares and rabbits have twenty-eight teeth. The Sloth has eighteen teeth. The number of teeth, thirty-two, which characterizes man, the apes of the old world, and the true Ruminants, is the average one of the class Mammalia; but the typical number is forty-four.

The examples of excessive number of teeth are presented, in the order *Bruta*, by the Priodont Armadillo, which has ninety-eight teeth; and in the Cetaceous order by the Cachalot, which has upwards of sixty teeth, though most of them are confined to the lower jaw; by the common porpoise, which has between eighty and ninety teeth; by the Gangetic dolphin, which has one hundred and twenty teeth; and by the true dolphins (*Delphinus*), which have from one hundred to one hundred and ninety teeth, yielding the maximum number in the class *Mammalia*.

Where the teeth are in excessive number, as in the species above cited, they are small, equal, or sub-equal, and of a simple conical form; pointed, and slightly recurved in the common dolphin; with a broad and flattened base in the Gangetic dolphin; with the crown compressed, and broadest in the porpoise; compressed, but truncate, and equal with the fang, in the Priodon. The compressed triangular teeth become coarsely notched or dentated at the hinder part of the series in the great extinct cetaceous *Zeuglodon*. The simple dentition of the smaller Armadillos, of the Orycterope, and of the three-toed Sloth, presents a difference in the size, but little variety in the shape of the teeth, which are subcylindrical, with broad triturating surfaces; in the two-toed Sloth, the two anterior teeth of the upper jaw are longer and larger than the rest, and adapted for piercing and tearing.

Teeth of Mammals.

Teeth are fixed, as a general rule, in all *Vertebrata*, and the only known exceptions are those presented by certain species of fishes; *e. g.*, the Sharks, Lophioids, Goniodonts. In the higher Vertebrata the movements of the teeth depend on those of the jaw-bones to which they are affixed, but appear to be independent in the ratio of the size of the tooth to the bone to which it is attached. Thus the extent of rotatory movement to which the large perforated poison-fangs of the rattle-snake are subject, depends upon the rotation of the small maxillary bone; so, likewise, the seemingly individual movements of divarication and approximation observable in the large lower incisors of the *Bathyergus* and *Macropus*,[1] are due entirely to the yielding nature of the symphysis uniting the two rami of the lower jaw, in which those incisors are deeply and firmly implanted.

In man, where the premaxillaries early coalesce with the maxillary bones, where the jaws are very short, and the crowns of the teeth are of equal length, there is no interspace or "diastema" in the dental series of either jaw, and the teeth derive some additional fixity by their close apposition and mutual pressure. No inferior Mammal now presents this character; but its importance, as associated with the peculiar attributes of the human organization, has been somewhat diminished by the discovery of a like contiguous arrangement of the teeth in the jaws of a few extinct quadrupeds; *e. g.*, *Anoplotherium*, *Nesodon*, and *Dichodon*.

Development

The teeth in the Mammalia, as in the foregoing classes, are formed by superaddition of the hardening salts to pre-existing moulds of animal pulp or membrane, organized so as to insure the arrangement of the earthy particles according to that pattern which characterizes each constituent texture of the tooth.

The complexity of the primordial basis, or matrix, corresponds, therefore, with that of the fully-formed tooth, and is least remarkable in those conical teeth which consist only of dentine and cement. The primary pulp, which first appears as a papilla rising from the free surface of the alveolar gum, is the part of the matrix which, by its calcification, constitutes the dentine. In the simple teeth, the secondary, or enamel pulp, covers the dentinal pulp like a cap; in the complex teeth it sends processes into depressions of the coronal part of the dentinal pulp, which vary in depth, breadth, direction, and number, in the different groups of the herbivorous and omnivorous quadrupeds. The dentinal pulp, thus penetrated, offers corresponding complications of form; and, as the capsule follows the enamel pulp in all its folds and processes, the external cavities or interspaces of the dentine become occupied by enamel and cement—the cement, like the capsule which formed it, being the outermost substance, and the enamel being interposed between it and the dentine. The dental matrix presents the most extensive interdigitation of the dentinal and enamel pulps in the Capybara and Elephant. The matrix of the mammalian tooth sinks into a furrow, and soon becomes inclosed in a cell in the substance of the jaw-bone, from which the crown of the growing tooth extricates itself by exciting the absorbent process, whilst the cell is deepened by the same process, and by the growth of the jaw, into an alveolus for the root of the tooth. Where the formative parts of the tooth are reproduced indefinitely, to repair, by their progressive calcification, the waste to which the working surface of the crown of the tooth has been sub-

[1] See Mason Good's *Book of Nature*, vol. i. p. 285. 1826.

Teeth of Mammals.

ject, the alveolus is of unusual depth, and of the same form and diameter throughout, except in the immature animal, when it widens to its bottom or base. In teeth of limited growth, the dentinal pulp is reproduced in progressively decreasing quantity after the completion of the exterior wall of the crown, and forms, by its calcification, one or more roots or fangs, which taper, more or less rapidly, to their free extremity. The alveolus is closely moulded upon the implanted part of the tooth; and it is worthy of special remark, that the complicated form of socket which results from the development of two or more fangs, is peculiar to animals of the class *Mammalia*.

In the formation of a single fang, the activity of the reproductive process becomes enfeebled at the circumference, and is progressively contracted within narrower limits in relation to a single centre, until it ceases at the completion of the apex of the fang, which, though for a long time perforated for the admission of the vessels and nerves to the interior of the tooth, is, in many cases, finally closed by the ossification of the remaining part of the capsule.

When a tooth is destined to be implanted by two or more fangs, the reproduction of the pulp is restricted to two or more parts of the base of the coronal portion of the pulp, around the centre of which parts the sphere of its reproductive activity is progressively contracted. The intervening parts of the base of the coronal pulp adhere to the capsule, which is simultaneously calcified with them, covering those parts of the base of the crown of the tooth with a layer of cement. The ossification of the surrounding jaw, being governed by the changes in the soft but highly organized dental matrix, fills up the spaces unoccupied by the contracted and divided pulp, and affords, by its periosteum, a surface for the adhesion of the cement or ossified capsule covering the completed part of the tooth.

The matrix of certain teeth does not give rise, during any period of their formation, to the germ of a second tooth, destined to succeed the first. This, therefore, when completed and worn down, is not replaced; all the true *Cetacea* are limited to this simple provision of teeth. In the Armadillos, Megatherioids, and Sloths, the want of germinative power, as it may be called, in the matrix, is compensated by the persistence of the matrix, and by the uninterrupted growth of the teeth. In most other Mammalia, the matrix of the first developed tooth gives origin to the germ of a second tooth, which sometimes displaces, sometimes takes its place by the side of, its predecessor and parent. All those teeth which are displaced by their progeny are called temporary, deciduous, or milk teeth (fig. 17, *d i-d*, 4). The mode and direction in which they are displaced and succeeded, viz., from below upwards in the lower jaw, in both jaws vertically, are the same as in the crocodile; but the process is never repeated more than once in any mammiferous animal. A considerable proportion of the dental series is thus changed; the second, or permanent teeth (fig. 17, *i* 1-*p*, 4), having a size and form as suitable to the jaws of the adult as the displaced temporary teeth were adapted to those of the young animal.

The permanent teeth (fig. 17, *m* 1-*m*, 3), which assume places not previously occupied by deciduous ones, are always the most posterior in their position, and generally the most complex in their form. The successors of the deciduous incisors and canines differ from them chiefly in size. The successors of the deciduous molars may differ likewise in shape, in which case they have always less complex crowns than their predecessors.

Teeth of Mammals.

The "bicuspids" in human anatomy, and the corresponding teeth called "premolars" in the lower mammals, illustrate this law.

The Mammalian class might be divided, in regard to the succession of the teeth, into two groups—the *Monophyodonts*,[1] or those that generate but one set of teeth, and the *Diphyodonts*,[2] or those that generate two sets of teeth. The Monophyodonts include the *Cetacea* and the *Bruta* (*Edentata* of Cuvier); all the other orders are Diphyodonts.

Form.

The teeth of the Mammalia, especially of the Diphyodonts, have usually so much more definite and complex a form than those of fishes and reptiles, that three parts are recognised in them, viz. the "fang," the "neck," and the "crown." The fang or root (*radix*) is the inserted part; the crown (*corona*) is the exposed part; and the constriction which divides these is called the neck (*cervix*). The term "fang" is properly given only to the implanted part of a tooth of restricted growth, which fang gradually tapers to its extremity; those teeth which grow uninterruptedly have not their exposed part separated by a neck from their implanted part, and this generally maintains to its extremity the same shape and size as the exposed crown.

Fixation.

It is peculiar to the class Mammalia to have teeth implanted in sockets by two or more fangs; but this can only happen to teeth of limited growth, and generally characterizes the molars and premolars; perpetually growing teeth require the base to be kept simple and widely excavated for the persistent pulp (figs. 54 and 55). In no mammiferous animal does anchylosis of the tooth with the jaw constitute a normal mode of attachment. Each tooth has its particular socket, to which it firmly adheres by the close co-adaptation of their opposed surfaces, and by the firm adhesion of the alveolar periosteum to the organized cement which invests the fang or fangs of the tooth.

Situation.

True teeth implanted in sockets are confined, in the Mammalian class, to the maxillary, premaxillary, and mandibular or lower maxillary bones, and form a single row in each. They may project only from the premaxillary bones, as in the Narwhal, or only from the lower maxillary bone, as in Ziphius; or be apparent only in the lower maxillary bone, as in the Cachalot; or be limited to the superior and inferior maxillaries, and not present in the premaxillaries, as in the true Ruminants and most *Bruta*.

Substance.

The teeth of the Mammalia usually consist of hard unvascular dentine, defended at the crown by an investment of enamel, and everywhere surrounded by a coat of cement. The coronal cement is of extreme tenuity in Man, Quadrumana, and terrestrial Carnivora; it is thicker in the Herbivora, especially in the complex grinders of the Elephant, and is thickest in the teeth of the Sloth, Megatherium, Dugong, Walrus, and Cachalot. Vertical folds of enamel and cement penetrate the crown of the tooth in the Ruminants, and in most Rodents and Pachyderms, characterizing by their various forms the genera of the last two orders; but these folds never converge from equidistant points of the circumference of the crown towards its centre. The teeth of the quadrupeds of the order *Bruta* (*Edentata*, Cuv.) have no true enamel; this is absent likewise in the molars of the Dugong and the Cachalot. The tusks of the Narwhal, Walrus, Dinotherium, Mastodon, and Elephant, consist of modified dentine, which, in the last two great proboscidian animals, is properly called "ivory," and is covered by cement.

Kinds.

The Dolphins and Armadillos present little variety in the shape of the teeth in the same animal, and this

[1] μόνος, once; φύω, I generate; οδους, tooth.

[2] δις, twice; φύω, and οδους.

Teeth of Mammals.

sameness of form is characteristic of most of the Monophyodonts, in which, therefore, the teeth are not divisible into distinct kinds.

In almost all the other Mammalia, particular teeth have special forms for special uses: thus, the front teeth, from being commonly adapted to effect the first coarse division of the food, have been called cutters or *incisors;* and the back teeth, which complete its comminution, grinders or *molars;* large conical teeth, situated behind the incisors, and adapted by being nearer the insertion of the biting muscles, to act with greater force, are called holders, tearers, laniaries, or more commonly *canine* teeth, from being well developed in the dog and other Carnivora, although they are given, likewise, to many vegetable feeders for defence or combat; *e. g.*, Musk-deer. Molar teeth, which are adapted for mastication, have either tuberculate, or transversely rigid, or flat summits, and usually are either surrounded by a ridge of enamel, or are traversed by similar ridges arranged in various patterns. Certain molars in the Dugong, the Mylodon, and the Zeuglodon, are so deeply indented laterally by opposite longitudinal grooves, as to appear, when abraded, to be composed of two cylindrical teeth cemented together, and the transverse section of the crown is bilobed. The teeth of the *Glyptodon* were fluted by two analogous grooves on each side. The large molars of the Capybara and Elephant have the crown cleft into a numerous series of compressed transverse plates, cemented together side by side. The modifications of the crown of the molar teeth are those that are most intimately related to the kind of food of the animal possessing them. Thus, in the purely carnivorous mammals, the molars are simple, trenchant, and play upon each other like scissor-blades. In the mixed feeding species, the working surface of the molars becomes broader and tuberculated; in the insectivorous species it is bristled with sharp points; and in the purely herbivorous kinds, the flat grinding surface of the teeth is complicated by folds and ridges of the enamel entering the substance of the tooth, the most complex forms being presented by the Elephants.

Ornithorhynchus.

The substances serving for teeth in the anomalous Duck-mole or Platypus of Australia, are of a horny texture, consisting of close-set, vertical hollow tubes, resembling the outer compact tissue of baleen or "whalebone." They are eight in number, four in the upper, and as many in the under jaw. The anterior tooth of the upper jaw (fig 48, *a*) is extended from behind forwards, but is low, very narrow,

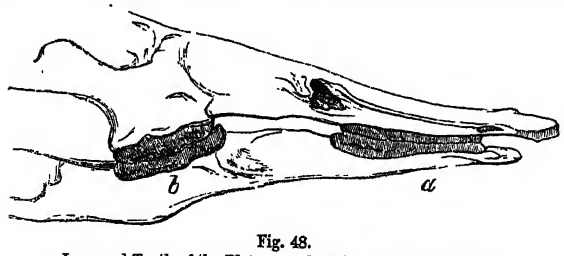

Fig. 48.
Jaws and Teeth of the Platypus, (*Ornithorhynchus paradoxus*).

and four-sided; the broadest side forms the base of attachment, and is slightly concave; the outer and inner facets converge to a serrated edge in the young *Ornithorhynchus*, but becomes worn in the old animal, and forms the fourth side of the tooth. The corresponding tooth in the lower jaw is rather narrower, and retains longer its trenchant edge.

At a distance from the anterior tooth, equal to its own length, is situated the horny molar (*b*), which consists of a flattened plate of an oblong subquadrate figure. A slightly raised margin includes two large concave surfaces, a little elevated above the intervening part of the grinding surface. The corresponding tooth in the lower jaw is somewhat narrower, but of similar form. Each division or tubercle of the molar is separately developed, and they become confluent in the course of growth. According to the analysis of Lassaigne, 99·5 parts of the dental tissue of the Ornithorhynchus have the composition of horn; this is hardened by 0·3 parts of phosphate of lime.

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The notice of the dental apparatus of the Monotremes ought to include mention of the two short and thick conical processes which project from the forepart of the raised intermolar portion of the tongue, in the *Ornithorhynchus;* which, like the more numerous spines on the corresponding part of the tongue of the Echidna, represent, in these low-organized mammals, the lingual teeth of fishes.

Order Bruta.

The teeth of the Orycterope, or Cape Ant-eater, are of a simple form, but peculiar structure; their common number in the mature animal is $\frac{7}{6}\cdot\frac{7}{6}=26$ (fig. 49, *A*), and they all belong to the molar series.

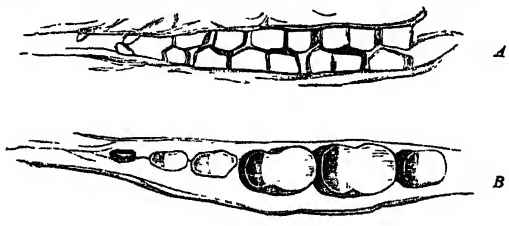

Fig 49.
Teeth of the Cape Ant-eater, (*Orycteropus.*)

The anterior teeth are very small, and are not unfrequently wanting, or are concealed by the gum, especially the first in the upper jaw; the second tooth of the upper jaw is small, compressed, and obtuse; it opposes a similar one in the lower jaw; the third and fourth molars increase in size, have an elliptical transverse section, and a triturating surface of two facets (fig. 49, *B*); the fourth and fifth molars are the largest in the upper jaw, are of equal size, and have a longitudinal depression in their internal and external sides, giving their transverse section a bilobed or hour-glass figure; the seventh molar is smaller and has the same simple figure as the fourth, (fig. 49, *B*). The proportions of these teeth, the depth of their sockets, and their structure, as viewed in longitudinal section with the naked eye, are shown in fig. 50. The teeth are continued solid, and of the

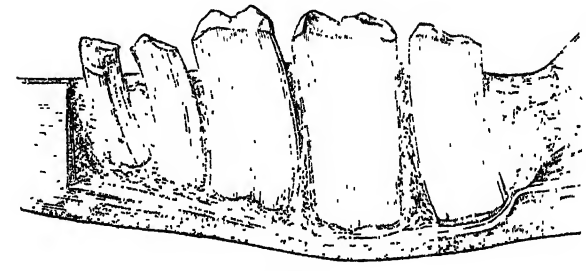

Fig. 50
Section of Lower Jaw and Teeth of the *Orycteropus.* Nat. size.

same dimensions, to the bottom of the socket, and terminate by a truncate and undivided base. If each be viewed as an aggregate of teeth, as partially shown in fig. 15, it will be found that the component denticle has its base excavated by a conical pulp-cavity, as in other animals, and which is persistent, as in the rest of the order *Bruta.* The wide inferior apertures of these pulp-cavities constitute the pores observable on the base of the compound tooth of the Orycterope, and give to that part a close resemblance to the section of a cane. The canals to which these pores lead are the centres of radiation of the calciferous tubes of the denticle, (fig. 15); such denticles are cemented together laterally, slightly decreasing in diameter, and occasionally bifurcating as they approach the grinding surface of the tooth. The substance of the entire tooth thus resembles the teeth of the *Myliobates* and *Chimæroids* among fishes, rather than any true teeth in the Mammalian class, in which it offers a transitional step from the horny substitutes of teeth above described to the true teeth.

The teeth of the *Orycteropus*, when rightly understood, offer, however, no anomaly or exceptional condition in their mode of development. Each denticle is developed according to the same laws, and by as simple a matrix as those larger teeth in other mammals, which consist only of dentine and cement. The dentine is formed by ossification of the capsule; both pulp and capsule continue to be reproduced at the bottom of the alveolus, *pari passu* with the attrition of the exposed crown; and the mode and time of growth being alike in each denticle, the whole compound tooth is maintained throughout the life of the animal. The augmentation in the size of the whole tooth, during the growth of the jaw, is effected by the development of new denticles, and a slight increase of size in the old ones, at the base of the growing tooth, which, in the progress of attrition and growth, becomes its grinding surface.

Genus Dasypus.

The teeth of the Armadillo-tribe are harder than those of any other species of the order *Bruta;* but, as in all that order provided with teeth, they are wholly devoid of enamel. They consist, in

Teeth of Mammals.

both existing and extinct Armadillos, of three distinct substances, of which the unvascular dentine is present in greatest proportion, and forms the main body of the tooth; but it includes a small central axis of vascular dentine, and is surrounded by an extremely thin coating of cement. The teeth are more numerous in the Priodon—the largest of the existing Armadillos—than in any other land mammal; but they are of very small size and simple form, and are all referable to the molar series (fig. 51). They vary

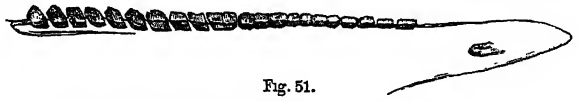

Fig. 51.

Teeth of the Lower Jaw of the Great Armadillo, (*Priodon gigas*).

in number from twenty-four to twenty-six in each upper jaw, and from twenty-two to twenty-four on each side of the lower jaw, amounting to from ninety-four to one hundred in total number. They are compressed laterally, increasing in size, and especially in breadth, as they recede backwards, with oblique or horizontal flat grinding surfaces, and are continued of the same size and form to their implanted extremity, which is excavated by a large conical pulp-cavity. This absence of roots, and the undivided hollow base indicative of the constant growth of the tooth, are common not only to the teeth of the Armadillos, but to those of all the known species of the order *Bruta*.

In the Priodont the teeth, though so unusually numerous, are many of them separated by slight intervals; those of the lower jaw oppose their outer sides to the inner sides of the upper teeth when the mouth is shut.

The Armadillos of the sub-genus *Euphractus*, Wagler, to which the term *Dasypus* is restricted by F. Cuvier, are distinguished by having the anterior tooth (fig. 52, *i*), which is shaped like the succeeding molar, implanted in the premaxillary bone. The two anterior teeth of the lower jaw being in advance of the premaxillary tooth, are, with it, arbitrarily held to be incisors; they are compressed, but are terminated by obtuse crowns. The rest of the series, from which the incisors are not separated by any remarkable interval, gradually increase in size to the penultimate molar; they have the same alternate position and obliquely-worn grinding surfaces as in the *Tatusiæ*.

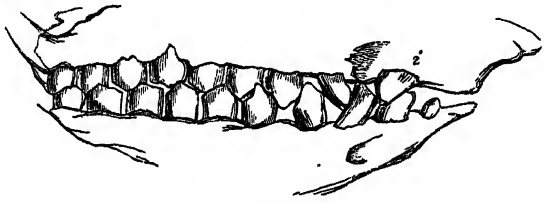

Fig. 52.

Jaw teeth of the weasel-headed Armadillo, (*Dasypus 6-cinctus*).

Fig. 53.

Tooth of great extinct Armadillo, (*Glyptodon clavipes*).

Some species of the extinct loricate genus, *Glyptodon*, surpassed the Rhinoceros in size, and the dentition of the genus was more complicated, and more adapted to a vegetable diet, than that of the small existing Armadillos. The total number of teeth in the Glyptodon has not yet been determined. A fragment of the anterior part of the lower jaw shows that the teeth extend close to the symphysis, and therefore indicates their presence in the premaxillary bones above.

The single tooth (fig. 53), on which the generic character of the Glyptodon was founded,[1] is long, rootless as in the existing Armadillos, but compressed laterally, and divided by two deep angular, longitudinal, and opposite grooves on each side, into three plates, which give the grinding surface the form of as many rhomboidal lobes. In the Glyptodon the osteo-dentine (fig. 53, *o*) occupies a larger proportion of the centre of the tooth than in the small Armadillos; it is harder than the dentine (*d*) or cement (*c*), and rises upon the grinding surface, in the form of a ridge extending along the middle of the long axis of that surface, and in three shorter ridges at right angles to the preceding, at the middle of each of the three rhomboidal divisions of the tooth.

Sloths.

Of the leaf-eating species of the order *Bruta*, very few, and these the most diminutive of the tribe, now exist. They are called Sloths, or Tardigrades, from their inability to move otherwise than slowly and with difficulty on the ground; but they are excellent climbers, for which their organization especially befits them.

Teeth of Mammals.

The following are the common and constant characters of the dentition of the phyllophagous *Bruta*, both recent and extinct:—Teeth implanted in the maxillary and mandibular bones, few in number, not exceeding $\frac{5}{4}:\frac{5}{4}$; composed of a large central axis of vaso-dentine, with a thin investment of hard dentine, and a thick outer coating of cement. To these, of course, may be added the dental characters common to the order *Bruta*, viz., uninterrupted growth of the teeth, and their concomitant implantation by a simple, deeply-excavated base, not separated by a cervix from the exposed summit or crown.

The dental formula of the genus Bradypus is—$i\ \frac{2}{3}$; $c\ \frac{1}{1}$; $m\ \frac{5}{4}:\frac{5}{4}$ = 18. Dr Brandt[2] has described and figured the skull of a young Ai, in which a very small tooth preceded the compressed one on each side of the lower jaw, rendering the number of teeth equal to that in the upper jaw. In the two-toed sloth (*Cholœpus didactylus*, Illig) the teeth (fig. 54) offer a greater inequality of size than has yet been observed in any other genus of *Bruta;* the first of each series, *a*, in both jaws, which in the rest of the order is the smallest, here so much exceeds the others as, with its peculiar form, to have received the name of a canine. This tooth is separated by a marked interval from the other teeth, especially in the upper jaw, so that those above play upon the anterior part of those below, contrary to the relative position and mutual action of the true canine teeth in the *Quadrumana* and *Carnivora*. They are of a triedral form, with the margins of the oblique abraded surface leading to the point, trenchant. The second tooth of the upper jaw (*b*) is the smallest of the series. The third (*c*) and fourth (*d*) molars are a little larger, and have two abraded surfaces which converge to the median ridge. The fifth molar (*e*) is the smallest, and has an oblique grinding surface. In each tooth the ridge is formed by the hard dentine, and is interrupted in the middle by an excavation of the soft dentine. The second, third, and fourth teeth of the lower jaw correspond in size and shape with the third and fourth above; and like the small upper molars, are separated by short intervals; the last is the smallest and most curved.

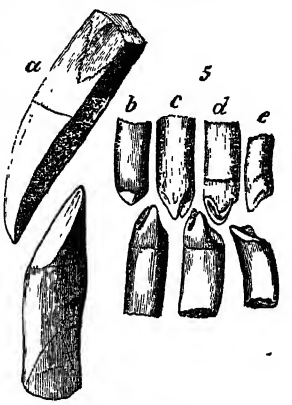

Fig. 54.

Teeth of the two-toed Sloth (*Cholœpus, didactylus*).

The teeth of the Sloths consist of a central axis of vaso-dentine (fig. 9, *v*), occupying rather more than half the thickness of the tooth, which is inclosed by a wall of unvascular dentine (*d*), and this by one of cement (*c*) of less thickness than the layer of hard dentine.

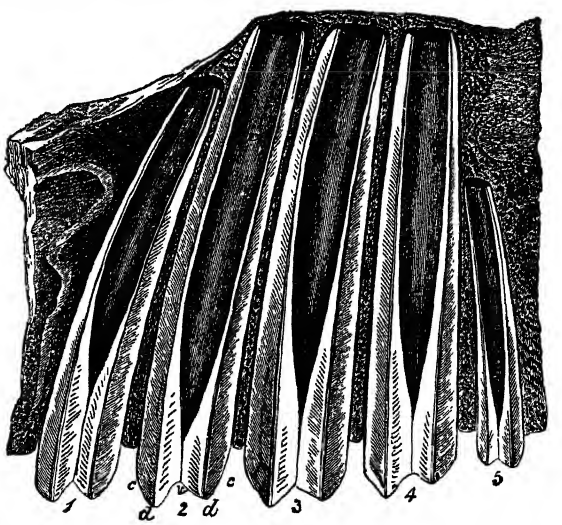

Fig. 55.

Section of Upper Jaw and Teeth of the Megatherium. One-third nat size.

The teeth of the *Megatherium*, the most gigantic of the extinct Megatherium.

[1] *Geological Transactions*, 2d Series, vol. vi. p. 81-85.

[2] *Dissertatio Zoologica inauguralis de Tardigradis*, 4to, 1828, p. 31, pl. 2, figs. 5 and 6.

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quadrupeds of the Sloth tribe, are five in number on each side of the upper jaw (fig. 55), and four on each side of the lower jaw (fig. 56). They are more closely arranged, and longer, and more deeply implanted, than in the smaller Megatherioids, *e. g.*, *Mylodon*, *Megalonyx*, etc. They present a more or less tetragonal figure, and have the grinding surface traversed by two transverse angular ridges. Fig. 55 exhibits a longitudinal section of the five molars of the upper jaw, *in situ*, and demonstrates the great extent of the implanted part of the tooth; the natural length of the series of five grinders is ten inches.

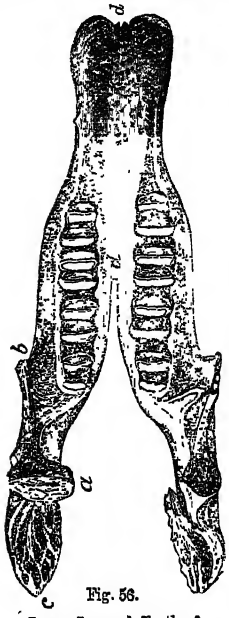

Fig. 56.
Lower Jaw and Teeth of Megatherium.

Each molar tooth of the Megatherium is excavated by an unusually extensive conical pulp-cavity (*p*), from the apex of which a fissure is continued to the middle depression of the grinding surface of the tooth (*v*). The central axis of vaso-dentine (*v*) is surrounded by a thin layer of hard or unvascular dentine (*d*), and this is coated by the cement (*c c*), which is of great thickness on the anterior and posterior surfaces, but is thin where it covers the outer and inner sides of the tooth. The vaso-dentine (fig. 57, *v*) is traversed throughout by medullary canals, measuring $\frac{1}{1500}$ of an inch in diameter, which are continued from the pulp-cavity, and proceed, at an angle of 50°, to the plane of the hard dentine, parallel to each other, with a slightly undulating course, having regular interspaces equal to one diameter and a half of their own area, generally anastomosing in pairs by a loop (*l l*), the convexity of which is turned towards the origin of the tubes of the hard dentine, forming a continuous reflected canal. The loops are situated near, and for the most part close to, the hard dentine (*d*). In a few places one of the medullary canals may be observed to extend across that tissue.

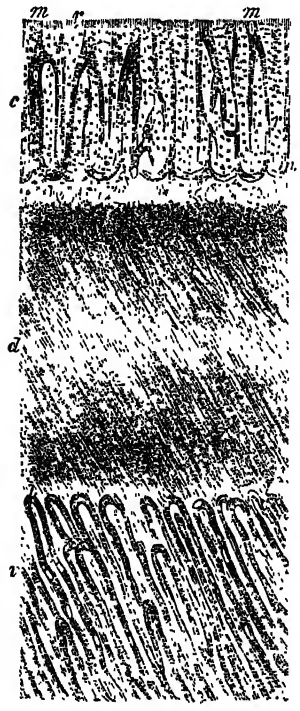

Fig. 57.
Highly magnified Section of the Dental Tissues, Megatherium.

The cement (fig. 57, *c*) is characterized by the size, number, and regularity of the vascular or medullary canals (*m*) which traverse it. They present the diameter of $\frac{1}{1500}$ of an inch, are separated by intervals equal to from four to six of their own diameters. Commencing at the outer surface of the cement, they traverse it in a direction slightly inclined from the transverse axis towards the crown of the tooth, running parallel to each other; they divide a few times dichotomously in their course; and finally anastomose in loops, the convexity of which is directed towards, and in most cases is in close contiguity with, the hard dentine (*d*). Fine tubules are sent off, generally at right angles from the medullary canals, which quickly divide and subdivide, form anastomosing reticulations, and communicate freely with the similar tubes that radiate from the calciferous cells of the intervening tissue (*r*).

The tooth of the Megatherium thus offers an unequivocal example of a course of nutriment from the dentine to the cement, and reciprocally. In the structure which the fossil teeth of the Megatherium and its extinct congeners clearly demonstrate, we have striking evidence of their rich organization, and that they were once pervaded by vital activity. All the constituents of the blood freely circulated through the vascular dentine and the cement, and the vessels of each substance, intercommunicated by a few canals, continued across the hard or unvascular dentine.

With respect to those minuter tubes, the more important as being more immediately engaged in nutrition, which pervade every part of the tooth, characterizing by their difference of length and course the three constituent substances, they form one continuous and freely intercommunicating system of strengthening and reparative vessels, by which the plasma of the blood was distributed throughout the entire tooth, for its nutrition and maintenance in a healthy state. Teeth of Mammals.

The grinding surface of the close-set molars of the Megatherium differs, on account of the greater thickness of the cement on their anterior and posterior surfaces, from those of all the smaller Megatherioids, in presenting two transverse ridges (fig. 56, *d*), one of the sloping sides of each ridge being formed by the cement (fig. 55, *c*), the other by the vascular dentine (fig. 55, *v*), whilst the unvascular dentine (*d*), as the hardest constituent, forms the summit of the ridge like the plate of enamel between the dentine and cement in the Elephant's grinder. The great length of the teeth, and concomitant depth of the jaws, the close-set series of the teeth, and the narrow palate, are also strong features of resemblance between the Megatherium and Elephant in their dental and maxillary organization. In both these gigantic phyllophagous quadrupeds, provision has likewise been made for the maintenance of the grinding machinery in an effective state throughout their prolonged existence; but the fertility of the creative resources is well displayed by the different modes in which this provision has been effected; in the Elephant, it is by the formation of new teeth to supply the place of the old when worn out; in the Megatherium, by the constant repair of the teeth in use, to the base of which new matter is added in proportion as the old is worn away from the crown. Thus, the extinct Megatherioids had both the same structure and mode of growth and renovation of their teeth as are manifested in the present day by the diminutive Sloths.

Whales.

Those cetaceous Mammals which are properly called "Whales" have no teeth, but horny substitutes in the form of plates, terminating or fringed by bristles. Of these plates, called "Baleen" and "Whalebone," the largest, which are of an equilateral triangular form, are arranged in a single longitudinal series on each side of the upper jaw, situated pretty close to each other, depending vertically from the maxillary bones, with their flat surfaces looking backwards and forwards, and their unattached margins outwards and inwards, the direction of their interspaces being nearly transverse to the axis of the skull. The smaller subsidiary plates are arranged in oblique series internal to the marginal ones. Thus, if the upper jaw of one side of the skull of a Whale were bisected transversely, the flat surface of a series of the baleen-plates would be exposed, as in fig. 58, in which *a* is the superior maxillary bone, *b* the ligamentous gum giving attachment to *c*, the horny base and body of the chief baleen-plate, which terminates in *d*, the fringe of bristles; *e* marks the smaller baleen-plates.

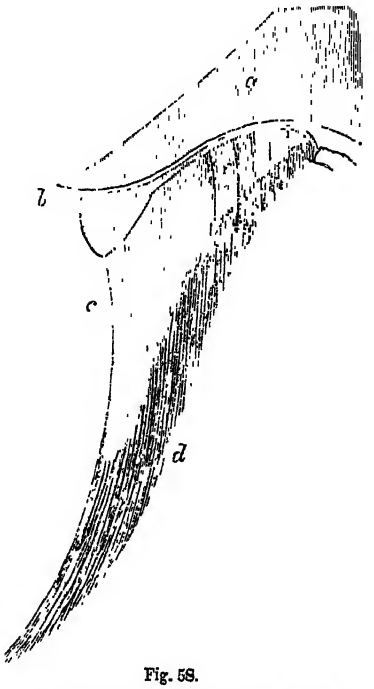

Fig. 58.
Section of Upper Jaw, with Baleen-plates, of a Whale (*Balænoptera*).

The base of each plate is hollow, and is fixed upon a pulp developed from a vascular gum, which is attached to a broad and shallow depression occupying the whole of the palatal surface of the maxillary and of the anterior part of the palatine bones, the Whale being thus, like Echidna, an example of a mammalian animal, which may be said to have palatal teeth. The base of each plate is unequally imbedded in a compact sub-elastic substance (*b*), which is so much deeper on the outer than on the inner side, as, in the new-born whale, to include more than one half of the outer margin of the baleen-plate. This margin is shown at *c* (fig. 58), and is continued downwards in a line dropped nearly vertically from the outer border of the jaws. The inner margin of each plate (*d*) slopes obliquely outwards from the base to the extremity of the preceding margin; the smaller plates decrease in length to the middle line of the palate, so that the form of the baleen-clad roof of the mouth is that of a transverse arch or vault, against which the convex dorsum of the thick and large tongue is applied when the mouth is closed. Each plate sends off from its inner and oblique margin the fringe of moderately stiff but flexible hairs, which project into the mouth.

The direction of the plates is not quite transverse at every part of

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the series; the inner border is turned rather forwards in the anterior, and obliquely backwards in the posterior plates; and the inner margin at the basal part of the posterior plates is slightly curved towards the back part of the mouth, to which the bristly terminations of these parts of such plates are directed, thus presenting an additional obstacle to the escape of the small marine animals,[1] for the prehension and detention of which this singular modification of the dental system is especially adapted. The baleen-pulp is situated in a cavity at the base of the plate, like the pulp of a true tooth; whilst the external cementing material maintains, both with respect to this pulp and to the portion of the baleen-plate which it developes, the same relations as the dental capsule bears to the tooth. According to these analogies, it must follow, that only the central fibrous or tubular portion of the baleen-plate is formed, like the dentine, by the basal pulp, and that the base of the plate is not only fixed in its place by the cementing substance or capsule, but must also receive an accession of horny material from it, as Hunter first indicated; this material answers to the cement of true teeth.

Mr Scoresby, who in his account of the *Balæna mysticetus*, notices only the large marginal plates, states that they are about two hundred in number on each side; the largest are from ten to fourteen feet, very rarely fifteen feet, in length, and about a foot in breadth at their base; these plates are overlapped and concealed by the under lip when the mouth is shut.

In the *Balænopteræ* or fin-backed whales (fig. 58), the baleen-processes (*e*), internal to the marginal plates, are fewer and smaller than in the *Balænæ*, the marginal plates (*c*) are more numerous, exceeding three hundred on each side; they are broader in proportion to their length, and much smaller in proportion to the entire animal; they are also more bent in the direction transverse to their long axis. As in the true whales, each plate of baleen consists of a central, coarse, fibrous substance, and an exterior, compact, fibrous layer, beyond which the central part projects in the form of the fringe of bristles.

A thin transverse section of baleen, viewed with a low magnifying power, demonstrates that the coarse fibres, as they seem to the naked eye, which form the central substance, are hollow tubes with concentric laminated walls. When a high magnifying power is applied to such a section, the concentric lines are shown not to be uniform, but interrupted here and there by minute elliptical dilatations, which are commonly more opaque than the surrounding substance, and which, like the radiated cells of true bone, are probably remains of the primitive cells of the formative substance; similar long elliptical opaque bodies or cells are dispersed irregularly through the straight parallel fibres of the dense outer laminæ of the baleen-plate.

The chemical basis of baleen, according to Brandt, is albumen hardened by a small proportion of phosphate of lime.

Rytina.

The singular armature of the palate and lower jaw, in the *Rytina*, or Arctic Dugong, likewise falls within the present category. According to Steller,[2] this marine animal has no true teeth, but only two large whitish dental masses, one adhering to the palate, the other to the opposed part of the lower jaw. They are not implanted by gomphosis, but adhere by numerous pores to corresponding papillæ of the membrane covering the palate and lower jaw; besides which, the palatal tooth is fixed at the sides of its anterior part to furrows in the lining membrane of the thick lip. The free surface of the dental mass is sculptured by undulating grooves and risings, adapted to corresponding inequalities in the opposite mass.

Dr Brandt has shown by later and more minute examination of the problematical teeth of the *Rytina*, deposited by Steller in the Petersburg collection, that their texture is horny, consisting of minute hollow fibres, placed vertically to the plane of the grinding surface of the tooth, but of unusual density. Thus the dentition of the Rytina closely resembles that of the *Ornithorhynchus* in both the texture and implantation of the teeth, which will probably be found to contain a similar or greater proportion of osseous matter. M. F. Cuvier has suggested that the above-described plates may be analogous in position, as in texture, to the horny covering of the opposed surfaces of the deflected portions of the upper and lower jaws in the Dugong.

Fœtal Whales.

The true Whales (*Balænidæ*), before they acquire their peculiar array of baleen-plates, manifest in their fœtal age a transitory condition of a true dental system, which, though abortive and functionless, beautifully typifies that which is normal and persistent in the majority of the order.

In an open groove (fig. 59, *a*) which extends along the alveolar border of both the upper and the lower jaws, there is a series of minute, conical, acute, or obtuse denticles, (fig. 59, 1-7), with hollow bases inclosing the uncalcified remains of a vascular pulp. In the fœtus of a *Balænoptera*, the jaws of which were about four inches in length, the unclosed alveolar groove of the upper jaw contained

Teeth of Mammals.

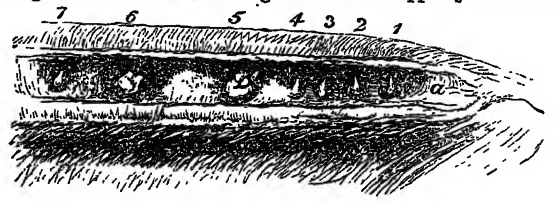

Fig. 59.
Extremity of Lower Jaw of a Fœtal Whale, with the Denticles. Nat. size.

twenty-eight such denticles, that of the lower jaw forty-two. The anterior denticles in both jaws were the smallest; but they increase in size more gradually, and maintain a greater regularity of form in the lower jaw, where they are also most numerous, and in which the typical dentition of the carnivorous cetaceans manifests its plenary development in the great Cachalot.

Fig. 60 exhibits three of the transitory teeth of a fœtal Whale: one is simple, with the fang contracted to a point by the diminution and cessation of growth; the next tooth shows two fangs; and the third, more plainly, the origin of its double character to two contiguous and partly confluent tooth-germs.

Fig. 60
Transitory Denticles of Fœtal Whale.

These small teeth and their matrices disappear before birth; yet the fœtal Whale comparatively long retains and palpably exemplifies the earliest stage of dental development in the higher Mammals, viz., the open fissure which in these is so rapidly closed, especially in the human subject. But beyond this stage, the true dentition of the *Balænidæ* is not destined to proceed, and they thus manifest, agreeably with the general laws of unity of organization, their closest relations to the typical characters of their order at the early periods of development—divesting themselves of part of the more general type, in order to assume their special and distinctive characters, as they advance towards maturity.

Hyperoodon.

The great Bottle-nose or bident Whale offers a transitional grade between the true Whales and the typical *Delphinidæ*. The palate is said to be beset with small, unequal, pointed, callous protuberances, which Cuvier conjectures to be rudimental baleen-plates. The fœtal denticles do not all perish, but two or three of the anterior pairs acquire a large size as compared with their transitory representatives in the *Balænidæ*—and one of these pairs is long retained in the lower jaw, though functionless, and hidden by the gum.

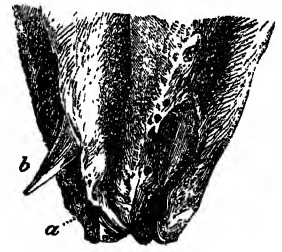

Fig. 61.
End of Lower Jaw, with the Teeth, of *Hyperoodon bidens*.

These teeth are figured, as seen, when the gum has been removed, at the extremity of the lower jaw of the *Hyperoodon*, in cut 61, *b*. They are conical, slightly curved, with an unusually sharp and slender apex, tipped by enamel. Though loose in their sockets, they project so little from them, and have such wide bases, that they are retained *in situ*, and do not fall out in the dried jaw; two smaller cavities (fig. 61, *a*) in front, and the remains of a larger socket in the alveolar groove, behind the retained teeth, attest the former presence of other teeth. Mr. Thompson of Belfast [3] has figured the lower jaw of a *Hyperoodon* with two small teeth on each side, near the symphysis; they were concealed by the gum, and so hidden in the sockets, as not to be visible in a side view of the jaw. The animal was a male, and twenty-three feet long; the first tooth was seven and a half lines from the end of the jaw; the second tooth was one and a half inch distant from the first.

Monodon.

In the Narwhal (*Monodon monoceros*), two of the primitive dental germs at the forepart of the upper jaw proceed in their development to a greater extent than do those in the lower jaw of the *Hyperoodon;* but every other trace of teeth is soon lost. The two persistent matrices rapidly elongate, but in the retrograde direction, forming a long fang rather than a crown; each tooth sinks into a horizontal alveolus of the premaxillary bone, or, rather, at the junction of the

[1] *Clio borealis, Limacina arctica*, and small pelagic Crustacea. Before the naturalists of the Arctic expeditions had determined the nature of the food of the true balænæ, John Hunter had stated, "I do suppose the fish they catch are small when compared with the size of the mouth."—"On the Structure and Economy of Whales."—*Phil. Trans.* 1787, p. 397.

[2] "Masticationem absolvant præter normam omnium animalium, non dentibus, quibus in universum carent, sed *duobus ossibus validis, candidis*, seu dentium integris massis, quarum una palato, altera maxillæ inferiori, infixa et huic opposita est. Insertio ipsa, seu connexio prorsus insolita, nec ulla prorsus nomine exprimi potest, gomphosin vocare non licet ob id, quod ossa non infiguntur maxillis, sed multis papillis et poris, poris et papillis reciprocis, palati et mandibulæ inferioris recipitur. Ossa hæc molaria subtus multis foraminulis pertusæ, velut netricum digitale vel spongia, quibus arteriæ et nervuli eodem modo ut dentibus animalium inseruntur, superna parte glabra sunt."—*Nov. Commentar. Petropolit.*, vol. ii. p. 302.

[3] *Annals of Natural History*, March 1846, pl. *a*.

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premaxillary with the maxillary, and soon, by the forward growth of these bones, becomes wholly inclosed, like the germs of the teeth of the higher Mammalia at their second stage of development. In the female Narwhal, the pulp is here exhausted, the cavity of the tooth is obliterated by its ossification, further development ceases, and the two teeth remained concealed, as abortive germs, in the substance of the jaws for the rest of life, so that in the skeleton a section of the skull must be made in order to display them, as in fig. 61, B. In the male Narwhal, (fig. 61, A) the matrix of the tooth in the left premaxillary bone continues to enlarge; fresh pulp material is progressively added, which by its calcification elongates the base, protrudes the apex from the socket, and the tusk continues to grow until it acquires the length of nine or ten feet, with a basal diameter of four inches. This is that famous "horn" which figures on the forehead

Teeth of Mammals.

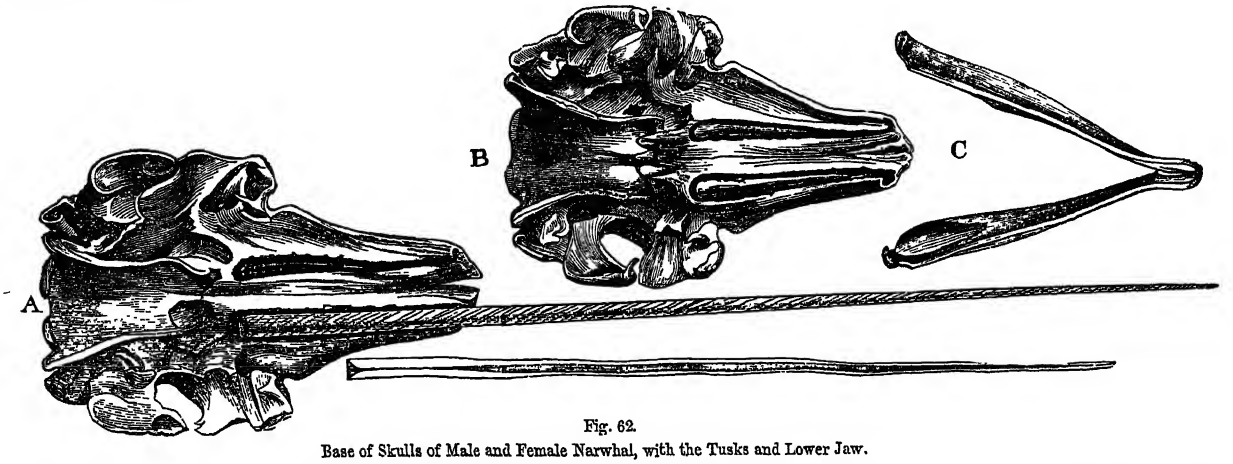


Fig. 62.

Base of Skulls of Male and Female Narwhal, with the Tusks and Lower Jaw.

of the heraldic unicorn, and so long excited the curiosity and conjectures of the older naturalists, until Olaus Wormius made an end of the speculative and fabulous "monocerologies," by the discovery of the true nature of their subject; whilst Anderson[1] in the year 1736, took advantage of the accident of the stranding of a Narwhal at the mouth of the Elbe, to communicate to the zoological world an accurate figure of the animal which bore the supposed single horn. Linnæus has embalmed the old idea of this weapon in the binomial *Monodon monoceros*, under which the Narwhal is entered in the *Systema Naturæ*.

The exterior of the long tusk is marked by spiral ridges, which wind from within forwards, upwards, and to the left. About fourteen inches is implanted in the socket; it tapers gradually from the base to the apex. The pulp-cavity, as shown in the longitudinal section of the tusk, given in fig. 62, is continued nearly to the extreme point, but is of variable width; at the base it forms a short and wide cone; it is then continued forwards, as a narrow canal, along the centre of the implanted part of the tooth, beyond which the cavity again expands to a width equalling half the diameter of the tooth; and finally, but gradually, contracts to a linear fissure near the apex.

Thus, the most solid and weighty part of the tooth is that which is implanted in the jaw, and nearest the centre of support, whilst the long projecting part is kept as light as might be compatible with the uses of the tusk as a weapon of attack and defence. The portion of pulp, in which the process of the calcification has been arrested, receives its vessels and nerves by the fissure continued from the basal expansion of the pulp-cavity.

In a few instances, both tusks have been seen to project from the jaw. In the cranium of such a Narwhal, figured by Albers, the right tusk projects only six inches from the socket, is proportionally slender, and is smooth.

With regard to the conjectured ulterior use of the concealed tusk (fig. 62, A), in the male, as a potential substitute, in the event of the loss of the large tusk, a conjecture more than once repeated by writers since first proposed by Reisel, the solidity of the concealed tusk, and its distorted and generally-closed base, evince that the term of its growth has expired.

In the *Delphinus griseus*, the dentition of the upper jaw is transitory, as in *Hyperoodon*, but at least six pairs of teeth rise above the gum, and acquire a full development at the forepart of the lower jaw. The crowns of these teeth soon become obtuse, and even their duration is limited, for the specimen described by M. F. Cuvier[2] had but two teeth on each side of the lower jaw. A Dolphin, perhaps an aged individual of this species, has been lately described with the dentition reduced to two teeth in the lower jaw.

Physeter.

The outward and visible dentition of the great Sperm-whale or Cachalot (*Physeter macrocephalus*) is confined to the lower jaw. The series consists in each ramus of about twenty-seven subincurved, conical, or ovoid teeth, according to their state of development and usage; the smallest teeth are at the two extremes of the series. In the young Cachalot they are conical and pointed; usage soon renders them obtuse, whilst progressive growth expands and elongates the base into a fang, which then contracts, and is finally solidified and terminated obtusely. The teeth are separated by intervals as broad as themselves. In respect of their mode of implantation in the jaw, they offer in the Cachalot a condition intermediate between that of the teeth of the extinct cetaceous-like *Ichthyosaurus*, and of those of the piscivorous *Delphinus*. They are lodged in a wide and moderately-deep groove, imperfectly divided into sockets, the septa of which reach only about half-way from the bottom of the groove. These sockets are both too wide and too shallow to retain the teeth independently of the soft parts, so that it commonly happens, when the dense semi-ligamentous gum dries upon the bone, and is stripped off in that state, that it brings away with it the whole series of the teeth like a row of wedges half driven through a strip of board. A firmer implantation would seem unnecessary for teeth which have no opponents to strike against, but which enter depressions in the opposite gum when the mouth is closed. That gum, however, conceals a few persistent specimens of the primitive fœtal series of teeth; these (of which one is shown at the upper part of fig. 63) are always much smaller and more curved than the functional teeth of the lower jaw, of which a section is given in the same cut.

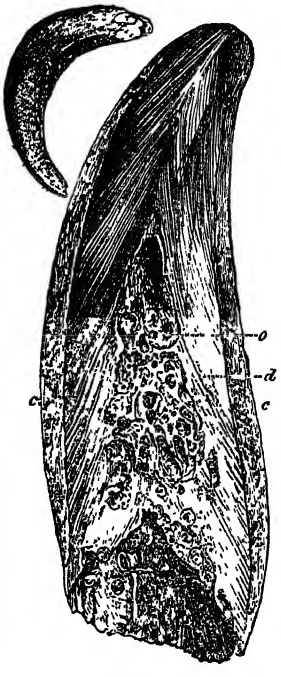


Fig. 63.

Rudimental Upper Tooth, and Section of a Functional Lower Tooth of the Cachalot, (*Physeter macrocephalus*).

There is a well-marked sexual distinction in the size of the jaws of the *Physeter macrocephalus*, those of the mature female being relatively shorter by full one-third than in the male. There are usually twenty-three teeth in each ramus of the lower jaw of a full-sized female Cachalot.

The first-formed extremity of the tooth in the young Cachalot is tipped with enamel; when the summit of the crown has been abraded, the tooth consists of a hollow cone of dentine (fig. 63, *d*), coated by cement (*c*), and more or less filled up by the ossified pulp (*o*). Irregular masses of this fourth substance have been found loose in the pulp-cavity of large teeth. The external cement is thickest at the junction of the crown and base, which are not divided by a neck.

Delphinus.

The permanent or mature dentition of the Beluga (*Delphinus leucas*, Pall.), though scanty, is more normal than in the Physeter, nine functional teeth being retained on each side of the upper jaw, and eight in each ramus of the lower jaw. They present the form of straight subcompressed obtuse cones. The *Delphinus globiceps*,

[1] Cited by Cuvier in his *Ossemens Fossiles*, tom. v. pt. i. p. 319.

[2] *Dents de Mammifere*, p. 243. It was eleven feet in length, and captured at Brest.

Teeth of Mammals.

which has $\frac{1}{2}\frac{4}{4}:\frac{1}{2}\frac{4}{4}=52$, strong, conical, and pointed teeth in the vigour of its age, begins soon after to lose them, and in old individuals none remain in the upper jaw, and not more than eight or ten are preserved in the lower jaw; those at the anterior part of the jaws last longest, and their summits are received in cavities in the upper jaw, or the gum covering it, when the mouth is shut.

The most formidable dentition is that of the predaceous Grampus (*Phocæna orca*), whose laniariform teeth are as large in proportion to the length of the jaws as in the crocodile; they are in number $\frac{1}{1}\frac{2}{2}\cdot\frac{1}{1}\frac{3}{3}=50$; all fixed in deep and distinct sockets, separated by interspaces which admit of the close interlocking of the upper and lower teeth when the mouth is closed; the longest and largest teeth are at the middle of the series, and they gradually decrease in size as they approach the ends, especially the posterior one; the shortness of the anterior teeth is in great part due to the wearing down of the sharp summits, which are best preserved in the small posterior teeth; the position of the bruising and piercing teeth being the reverse of what commonly obtains.

The tooth continues to expand below the enamelled crown to the middle of the fang, which is three times the length, or more, of the crown; it then gradually diminishes to a truncated base, more or less excavated, according to the age of the tooth. The expanded ventricose fang is subcompressed and flattened at the sides. A worn tooth of an old Grampus much resembles the canine of the *Ursus spelæus;* but the long ventricose fang of that is flattened only on one side, is convex at the other, and the pulp cavity is obliterated long ere the crown is worn down; the base of the enamel is more evenly circular, less oblique from the convex to the concave side of the crown; the fang in the Grampus is marked by many wavy transverse lines of growth.

In the common Dolphin the number of teeth amount to 190, arranged in equal numbers above and below, and there is a pair of teeth in the premaxillaries which are toothless in the other *Cetacea.* They have slender, sharp, conical, slightly incurved crowns, and diminish in size to the two extremes of the dental series; the acute apices are longer preserved than in the foregoing species.

The teeth of the common Porpoise (*Phocæna vulgaris*) are arranged in equal number on each side of both upper and lower jaws, and are from 80 to 92 in number; the crown is slightly expanded and compressed, and the fully-formed fang is recurved and enlarged at its extremity.

The Gangetic Dolphin (*Platanista gangetica*) differs from the rest of the *Delphinidæ* scarcely less in the form of its teeth than in that of the jaws. Both the upper and lower maxillary bones are much elongated and compressed; the symphysis of the lower jaw is coextensive with the long dental series, and the teeth rise so close to it, that those of one side touch the others by their bases, except at the posterior part of the jaw. The lateral series of teeth are similarly approximated in the upper jaw at the median line of union, which line is compelled, by the alternate position of the teeth, to take a wavy course.

There are thirty teeth on each side of the upper jaw, and thirty-two on each side of the lower jaw. In the young animal they are all slender, compressed, straight, and sharp pointed, the anterior being longer than the posterior ones, and recurved. Contrary to the rule in ordinary Dolphins, the anterior teeth retain their prehensile structure, while the posterior ones soon have their summits worn down to their broad bases.

The most remarkable change that occurs in the progress of growth is the antero-posterior expansion, as well as elongation of the implanted base of the tooth, which likewise has its outer surface augmented by longitudinal folds or indentations, analogous to, but weaker than, those in the base of the teeth of the Sauroid fishes. Sometimes the posterior tooth of the Platanista has the base divided into two short fangs—the sole example of such a structure which I have met with in the existing carnivorous Cetacea.

Fig. 64.
Section of Jaw and Teeth of a Dolphin (*Delphinus delphis*).

Development.

The primitive seat of the development of the tooth-matrix in the vascular membrane or gum (fig. 64, *a*) lining an open groove on the alveolar border of the maxillary bones (*b*), is maintained much longer in the *Cetacea* than in the highest organized *Mammalia;* a greater proportion of the tooth is also developed before the matrix sinks into, or is surrounded by a bony alveolus; and, with the exception of the rudimental tusks in the Narwhal, is at no period entirely enclosed in a bony cell; in which respect the *Cetacea* offer an interesting analogy to true fishes.

Teeth of Mammals.

The Cetacea permanently represent that early embryonic stage when no cervical constriction divides the large head from the trunk, and when the rudimental limbs offer no outward marks of joints or digits; they likewise retain a preponderating proportion of brain, and manifest for a long period, and on a magnified scale, the first stages in the development of teeth.

When, by the increasing depth of the jaw, and the reciprocal elongation of the tooth, its base or fang becomes supported by bone (fig. 64, *b*), a longer time than usual elapses before the alveolus is completed by the development of transverse partitions between the outer and inner walls of the open groove; and in the meanwhile the teeth are lodged, like those of the *Ichthyosauri*, in a common and continuous bony channel. In the *Delphinidæ* the teeth are successively developed from before backwards, and pass through all their stages of growth in that order of position—the anterior ones having their fangs and alveoli completed, whilst the posterior teeth are lodged in a common groove, or may be supported at the back part of the series by the gum only, as at *a*. When the formation of the entire series of teeth approaches its completion, the Dolphin resembles the Alligator in having the anterior teeth lodged in sockets, and the posterior teeth in an alveolar groove. In the Cachalot the large middle teeth of the series are the last to have the fang solidified. The conversion of the last remnant of the pulp produces the irregular bone-like deposit in the centre of the tooth, and closes up the lower aperture—one or two minute canals for the nutrient vessels being usually left. The mass of this fourth central substance is greatest in the Cachalot (fig. 63, *o*), in which the process sometimes commences at an independent centre, and proceeds centrifugally, as in ordinary ossification, giving rise to the detached stalactitic masses occasionally found loose in the unclosed pulp-cavity of large teeth.

Zeuglodon.

The remains of a gigantic animal discovered in a tertiary formation in the State of Louisiana, and originally interpreted to belong to the class of reptiles with the name of *Basilosaurus*,[1] having presented, in both portions of upper and lower jaws, teeth implanted by a double fang in deep sockets, the writer demonstrated from this character, and the microscopic structure of the teeth, both the mammalian nature and cetaceous affinities of the species, and proposed for it the name of *Zeuglodon*, or yoke-tooth.[2] The crowns of the large posterior teeth are sub-compressed and conical, with an obtuse apex. The upper part of the crown has its anterior and posterior margins strongly serrated (fig. 65). The crown is contracted from

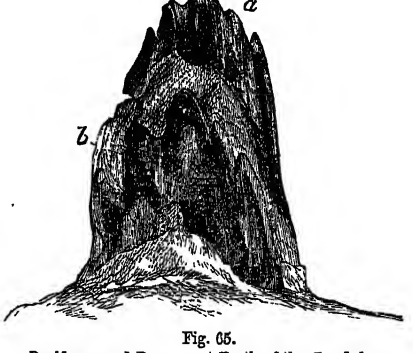


Fig. 65.
Deciduous and Permanent Teeth of the *Zeuglodon*.

side to side in the middle of its base, so as to give its transverse section an hour-glass form (fig. 66); and the opposite wide longitudinal grooves which produce this form, become deeper as the crown approaches the socket, and at length meet and divide the root of the tooth into two separate fangs. The anterior teeth have a single root, and are somewhat smaller than the posterior ones; the crown is sharp-pointed, conical, slightly recurved and laterally compressed, the transverse section of the base forming an ellipse.

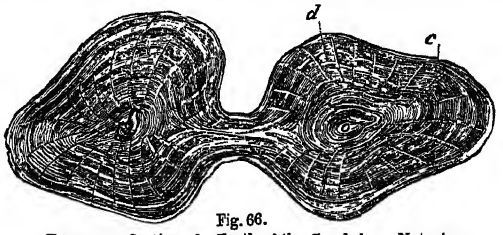


Fig. 66.
Transverse Section of a Tooth of the *Zeuglodon*. Nat. size.

[1] Harlan, *Medical and Physical Researches*, 8vo, 1835. Prof. R. Grant, in Thomson's *British Annual* for 1839.
[2] *Transactions of the Geological Society of London*, 2d Series, vol. vi.

Teeth of Mammals.

The teeth of a species of this genus were figured by Scilla in his work *De Corporibus Marinis*, 4°, 1747, tab. xii. fig. 1. They have been ascribed, since the above-cited memoir on *Zeuglodon* appeared, by Mr. Grateloup, to a genus called *Squalodon*, and by Dr. Gibbs to a genus called *Dorudon*. The mode of completion of the teeth in this extinct Cetacean is different from, and conforms to, a higher type than that of any of the existing carnivorous genera of the order. It is evident that the pulp which, from the form and structure of the crown, was originally simple, becomes afterwards divided into two parts, and that its calcification then proceeds towards two distinct centres, which are each separately surrounded by concentric striæ of growth. The *cavitas pulpi*, which is very small in the crown of the tooth, becomes contracted as the fangs descend, and is almost obliterated near their extremities.

The summits of the crown of the teeth of the *Zeuglodon* were sheathed with enamel. Their base exhibits an investment of a thin layer of cement, which augments in thickness where it surrounds the fangs.

Dr Carus[1] figures a fragment of the under jaw of the *Zeuglodon* (see fig. 65), in which a worn-out deciduous molar appears to be displaced and succeeded vertically by a premolar; this would imply an affinity to the *Sirenia*. In the *Sirenia*, whose dentition will next be described, the two-fanged structure is fully established in the Manatee, whilst the Dugong presents a near resemblance to the Zeuglodon in the composition and the intimate structure of the molar teeth. The vertebræ of the *Zeuglodon* resemble those of the carnivorous Cetacea. The size of the extinct animal is estimated at near seventy feet; it accordingly affords a very interesting addition to the history of the dental system in the Cetaceous order, and makes the typical group approach by another step nearer to the Dugongs and Manatees, which are more essentially related to the Pachyderms.

Order Sirenia.

Two marks of inferiority in the dental system of the carnivorous Cetacea, which they have in common with many of the order *Bruta*, viz.—uniformity of shape in the whole series of teeth, and no succession and displacement by a second or permanent set,—disappear when we commence the examination of the dentition of those apodal Pachyderms, which have been called by Cuvier the Herbivorous Cetacea.

Halicore.

In the Dugong (*Halicore*), for example, we find incisors distinguished by their configuration as well as position from the molars, and the incisive tusk is deciduous, displaced vertically, and succeeded by a permanent tusk; both these characters are shown in fig. 67. Of the incisors of the Dugong, only the superior ones project

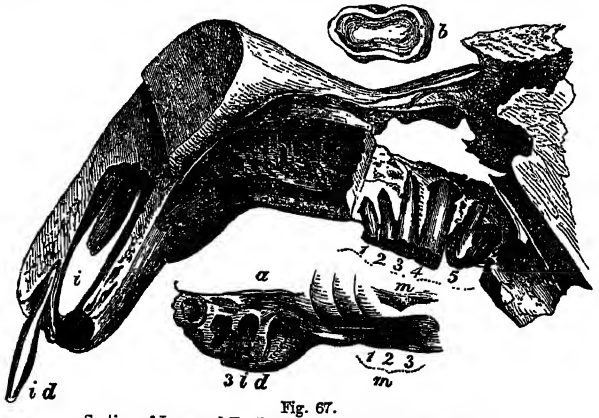


Fig. 67.
Section of Jaws and Teeth of a Dugong (*Halicore indicus.*)

from the gum in the male sex, and neither upper nor lower ones are visible in the female. The superior incisors (*i*) are two in number in both sexes. In the male they are moderately long, substriedral, slightly and equally curved, of the same diameter from the base to near the apex, which is obliquely bevelled off to a sharp edge, like the scalpriform teeth of the *Rodentia*. Only the extremity of this tusk projects from the jaw, at least seven-eighths of its extent being lodged in the socket, the parietes of which are entire, and the exterior of the great intermaxillary bones presents an unbroken surface. In the female Dugong the growth of the permanent incisive tusks of the upper jaw is arrested before they cut the gum, and they remain throughout life concealed in the premaxillary bones; the tusk in this sex is solid, is about an inch shorter and less bent than that of the male; it is also irregularly cylindrical, longitudinally indented, and it gradually diminishes to an obtuse rugged point; the base is suddenly expanded, bent obliquely outwards, and presents a shallow excavation. The deciduous incisors of the upper jaw (fig. 67, *i d*) are much smaller than the permanent tusks of the female,[2] and are loosely inserted by one extremity in conical sockets immediately anterior to those of the permanent tusks (fig. 67), adhering by their opposite ends to their tegumentary gum, which presents no outward indication of their presence. Not more than twenty-four molar teeth are developed in the Australian Dugong (*Halicore Australis*), or more than twenty molar teeth in the Malayan Dugong, viz.—in the latter, five on each side of both upper and lower jaws (fig. 67, 1-5), but these are never simultaneously in use, the first being shed before the last has cut the gum.

Teeth of Mammals.

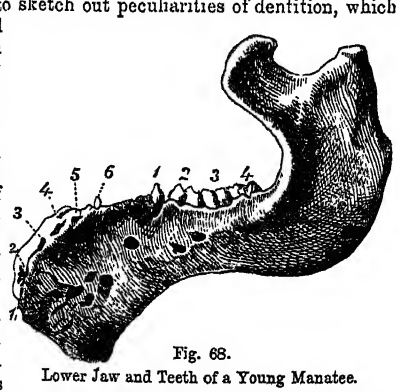
The period when the molar series can be viewed in its most complete state in the Dugong is that represented in fig 67. The molar teeth increase very regularly in size; the fang of the first (1) and of the second (2) is soon completed and solidified; that of the third (3) is more elongated, and retains its basal cavity longer, but it becomes at length contracted to a point, solidified, partially absorbed, and the tooth is then shed; the crown presents a regular oval shape in transverse section. The fourth molar, when fully formed, resembles a slightly bent cylinder with a nearly smooth outer surface; the crown is flat, or slightly depressed at the centre. The opposite extremity of the tooth is excavated by a regular conical cavity, lodging the remains of the pulp. With age, however, the fang contracts, takes on an irregularly fluted and tuberculate surface, and is at last closed at its extremity. The matrix of the last molar tooth (5) expands as the crown is forming, and manifests a tendency to divide into two fangs; but having acquired the size and form exhibited in fig. 67, *b*, in transverse section, the pulp is maintained in a wide basal pulp-cavity, to supply the waste of the crown according to that pattern.

The molar teeth of the Dugong consist of a large body of dentine (fig. 8, *d*), a small central part of osteo-dentine, and a thick external investment of cement (*c*). The communications between the tubes of the cement and those of the dentine are clearly discernible in several parts of the circumference of the latter substance, and the whole system of tubes adapted to circulate the plasma of the blood through the solid tissues of the tooth is, perhaps, in no existing mammal better seen than in the molar of the Dugong. The small portion of osteo-dentine in the centre of the tooth is permeated by a few vascular canals, which are derived from the remains of the pulp. In the female Dugong the whole of the smaller extremity of the tusk is surrounded by a thin coat of true enamel, which is covered by a thinner stratum of cement. In the male's tusk the enamel, though it may originally have capped the extremity, as in the female's, yet, in the body of the tusk, it is laid only upon the anterior convex, and on the lateral surfaces, but not upon the posterior concave side of the tusk; which is thickly coated with cement.

This side, accordingly, is worn away obliquely when the tusk comes into use, whilst the enamel maintains a sharp chisel-like edge upon the anterior part of the protruded end of the tusk.

The presence of abortive teeth concealed in the sockets of the deflected part of the lower jaw of the Dugong (fig. 67, *a*, *i d*) offers an interesting analogy with the rudimental dentition of the upper jaw in the Cachalot, and of both jaws in the fœtal Whales. The arrested growth and concealment of the upper tusks in the female Dugong, and the persistent pulp-cavity and projection of the corresponding tusks in the male, are equally interesting repetitions of the phenomena manifested on a larger scale in the singular dental system of the Narwhal; but the habitual abrasion to which the tusks of the male Dugong are subject prevents their closer resemblance to the male Narwhal's tusk in regard to length. The simple implantation of the molar teeth and their composition are paralleled in the teeth of the Cachalot; their difference of form, and the more complex shape of the hindmost tooth, are repetitions of characters which were present in the dentition of the extinct *Zeuglodon*.

The co-existence of incisive tusks with molar teeth, and the successive displacement of the smaller and more simple anterior ones by the advance of larger and more complex grinders into the field of attrition, already seem to sketch out peculiarities of dentition, which become established and attain their maximum in the Proboscidian family (Elephants and Mastodons) of the Ungulate order.



Manatus.

Fig. 68.
Lower Jaw and Teeth of a Young Manatee.

The transition from the cetaceous to the more normal type of pachydermal dentition is effected by the Manatee (*Manatus*), especially by the modification of the molar series.

The deflected anterior extremities of the intermaxillary bones each support a single deciduous tusk in the young Manatee (fig. 69, *i*): but this is not succeeded by a permanent one in either sex. Six depressions for rudimental teeth

[1] See Nova acta Cæs. Leop. Carol, vol. xxii. tab xxxix. B. fig. 2, p. 390.

[2] *Proceedings of the Zoolog. Society*, 1838, p. 41.

Teeth of Mammals.

occur in the gum, covering the deflected forepart of each ramus of the lower jaw in the young new-born American Manatee (fig. 68, 1-6), and in the sixth (6) Stannius[1] found a tooth, which he calls a sixth incisor.

The molars of the American Manatee are thirty-eight in number, ten on each side of the upper jaw, and nine, at least, on each side of the lower jaw; but they are never simultaneously in place and use. The number of teeth ordinarily in use at the same time is that represented in Fig. 69, 3-8, where the first and second molars (1, 2) have been shed, and the two last (9 and 10) have not come into place;

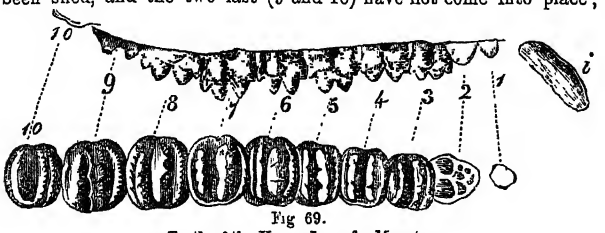


Fig 69.

Teeth of the Upper Jaw of a Manatee.

in the lower jaw seven molars are usually in use in the adult. The first (figs. 68 and 69, 1) in both jaws is small and simple. Beyond the second, the crowns in the upper jaw are square, and support two transverse ridges with tri-tuberculate summits, having also an anterior and posterior basal ridge; each tooth is implanted by three diverging roots, one on the inner and two on the outer side; they increase in size very gradually, from the foremost to the last.

The crowns of the four or five anterior molars of the lower jaw resemble those above, but the rest have a large posterior tubercle; they are all implanted by two fangs, which enlarge as they descend, and bifurcate at the extremity; the crowns are of moderate height, and project only a few lines above the sockets.

The molars consist of a body of dentine, a coronal covering of enamel, and a general investment of cement, very thin upon the crown, and a little thicker upon the fangs.

All the grinding teeth of the Manatee belong to the true molar series, in so far as that none are displaced by vertical successors; but the first molar (fig. 68, 1) is small, conical, and simple, and is separated by a brief interval from the first of the two-ridged molars (2 *e*). In this respect the Manatee manifests, like the Dugong, a cetaceous character, and the more strongly, inasmuch as the number of molars successively developed from before backwards is greater. The anterior teeth are, however, displaced before the posterior ones are developed, although they have no vertical successors; which circumstance is also characteristic of the Elephant, and the shape, the structure, and the mode of implantation of the molars of the Manatee, accord with the pachydermal type, and herein more especially with the teeth of the *Dinotherium* and *Tapir*.

Order Marsupialia.

In the Marsupial order, the typical number of the teeth in the molar series is seven on each side of both jaws, the first three of which displace as many milk teeth, and are "premolars" (fig. 76, *p* 1, 2, 3), the other four are true "molars," (fig. 76, *m* 1, 4). Incisors (fig. 71, *i*) are present in all the species, but are variable in number, in some genera exceeding that of the Mammalian type. Canines (fig. 71, *c*) are large in the Dasyures, are feebly represented in the Phalangers and Petaurists, are absent in the lower jaw of the Potoroos and Koala, and in both jaws of the Kangaroos and Wombats.

Thylacinus.

The Dasyures and Thylacine offer the carnivorous type of the dental system, but differ from the corresponding group of the placental Mammalia, in having the molars of a more uniform and simple structure, and the incisors in greater number; the dental formula of the Dog-headed Opposum, *Thalycinus*, is—

$$i\,\frac{4.4}{3.3};\ c\,\frac{1.1}{1.1};\ pm\,\frac{3.3}{3.3};\ m\,\frac{44}{44} = 46.$$

The canine teeth are long, strong, curved, and pointed, like those of the dog tribe; the points of the lower canines are received in hollows of the premaxillary palatal plate when the mouth is closed, and do not project, as in the carnivorous placentals, beyond the margins of the maxillary bones. The premolars (*p*) present a simple compressed conical crown, with a posterior tubercle, which is most developed on the hindmost. The true molars (*m*) in the upper jaw are unequally triangular, the last being much smaller than the rest; the exterior part of the crown (fig. 70, *a*, *b*) is raised into one large pointed middle cusp and two smaller cusps; a small strong obtuse lobe (*c*) projects from the inner side of the crown. The molars of the lower jaw are compressed and tri-cuspidate; the middle cusp being the longest, especially in the two last molars, which resemble closely the carnassial teeth (dents carnassières) of the dog and cat.

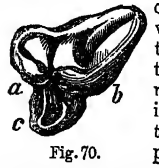


Fig. 70.

Penultimate Upper Molar of the Thylacine.

The dental formula of the genus *Dasyurus* is—

$$i\,\frac{4.4}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{2.2};\ m\,\frac{4.4}{4.4} = 42.$$

Teeth of Mammals.

Dasyurus.

The eight incisors of the upper jaw (fig. 70, *i*) are of the same

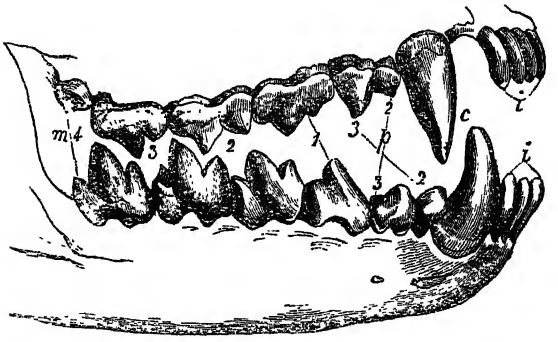


Fig 71.

Dentition of the Ursine Dasyure. Nat. size.

length and simple structure, and are arranged in a regular semicircle. The six incisors of the lower jaw (fig. 71, *i*) are similarly arranged, but have thicker crowns than the upper ones. The canines (fig. 71, *c*) present the same, or even a greater relative development, than in the Thylacine; in an extinct species of *Dasyurus*, they had the same form and relative proportions as in the Leopard. The premolars (*p* 2 and 3) answer to the two last in the Opossum, and have simple crowns. The upper true molars (*m*) have triangular crowns; the first presents four sharp cusps; the second and third each five; the fourth, which is the smallest, only three. In the lower jaw, the last molar is nearly of equal size with the penultimate one, and is bristled with four cusps, the external one being the longest. The second and third molars have five cusps, three on the inner and two on the outer side; the first molar has four cusps. The carnivorous character of the above dentition is most strongly marked in the Ursine Dasyure, or *Devil* of the Tasmanian colonists, the largest existing species of the genus.

Thylacoleo

A carnivorous Australian marsupial, of the size of a Lion, now extinct, which the writer determined under the name of *Thylacoleo carnifex*, in 1848, has a true carnassial tooth, upwards of an inch and a half in fore and aft extent, and one inch in height; consisting wholly of the "blade" in the lower jaw (fig. 72), and with the addition of a very feeble depressed tubercle in the upper jaw. On the occasion of a visit to London by M. Paul Gervais, at the period when the supposed marsupial character of the *Pterodon* or *Hynodon* (fig. 111) of the miocene deposits of Auvergne, Gard, and Vaucluse were under discussion, the writer took the opportunity to point out to that able comparative anatomist and palæontologist, certain characters deducible from the foramen caroticum and foramen lacrymale, bearing on this question, and illustrated those conclusions by reference to the then unique carnivorous fossil which had a short time before been transmitted from Australia. M. Gervais accordingly enters the genus *Thylacoleo* in the geographical table of fossil mammalia, of the "Zoologie and Paléontologie Française," and in his remarks on those of Australia (Nouvelle Hollande), he writes, "Les depôts pliocenes ou pleistocenes ont fourni des Grand Kangaroos, un grand Wombat,[2] divers autres espèces congenêrès de celles d'à present, les genres de *Diprotodon* et *Nototherium*, qui étaient aussi des Marsupiaux, mais dont les allues et la taille approchaient de celles de nos grands pachydermes Diluviens, et le Dasyurien, plus grand que le Lion, que M. Owen nomme *Thylacoleo*" (p. 192).

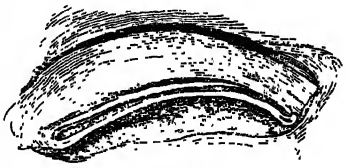


Fig. 72.

Lower Carnassial Tooth, viewed from above, of the Thylacoleo.

Phascogale

In some of the smaller species of the carnivorous group, as the Phascogale, the canines lose their great relative size, and the molar teeth present a surface more cuspidated than sectorial; there is also an increased number of teeth, and as a consequence of their equable development, they have fewer and shorter interspaces. The genus *Phascogale* is characterized by—

$$i\,\frac{4.4}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{4.4}{4.4} = 46.$$

In this dental formula may be discerned a step in the transition from the Dasyures to the Opposums, not only in the increased number of spurious molars, but also in the shape and proportions of the incisors.

[1] Beitrage zur Kenntniss der Amerikanischen Manati's, 4to, Rostock, 1845.

[2] That, viz., which is alluded to as being "at least four times as large as either of the known existing species," in the writer's memoir on the extinct species of *Phascolomys*.—(July 1845), *Trans. Zool. Soc.* tom. iii. p. 306.

Teeth of Mammals.

The general character of the dentition of these small predatory Marsupials approximates to the insectivorus type, as will be exemplified in the Shrew, Hedgehog, etc., among the placental Mammalia, and corresponds with the food and habits of the species, which thus lead from the predaceous, or flesh-feeding, to the Entomophegous tribes.

Phascolotherium.

The interval is further diminished by a lost Marsupial genus, which forms one of the ancient Mammalia that have rendered the oolitic formations at Stonesfield so famous. This genus, which the writer has called *Phascolotherium*,[1] presents the same numerical dental formula as in *Phascogale*, viz.—

$$i\,\frac{??}{3.3}\text{ or }4.4;\ c\,\frac{??}{1.1};\ p\,\frac{??}{3.3};\ m\,\frac{??}{4.4}\ \text{(Fig. 73).}$$

But the incisors (*i*) and canines (*c*) are separated by vacant interspaces, and occupy a larger proportional space in the dental series.

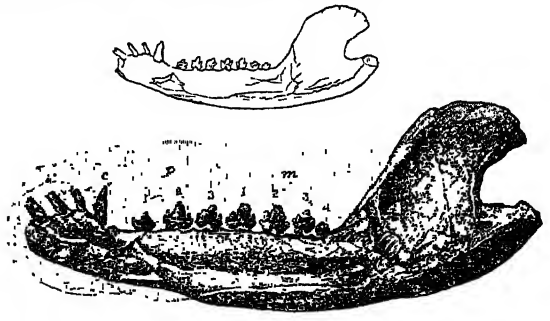


Fig. 73.

Lower Jaw and Teeth of the Phascolothere. Nat. size, in outline.

The transition from the false (*p* 1, 2, 3) to the true (*m* 1, 2, 3, 4) molars, is more gradual; the latter are more compressed than in the Opossum; the five larger teeth present each a large middle cusp, with a smaller one in front and behind it, and with a basal ridge, which, projecting a little beyond both the anterior and posterior smaller cusps, gives a quinque-cuspid character to the crown of the tooth.

Myrmecobius.

The *Myrmecobius* (fig. 74) is characterised by the following remarkable dental formula:—

$$i\,\frac{4.4}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{6.6}{6.6} = 54.$$

From this formula it will be seen that the number of true and false molars, eighteen in both jaws, exceeds that of any other known existing Marsupial. The molars (*m* 1, 6) present a distinct multicuspid structure, and both the true and false ones possess two separate fangs, as in other Marsupials. The inferior molars are directed obliquely inwards, and the whole dental series describes a slight sigmoid curve. The premolars (*p* 1, 2, 3) present the usual compressed triangular form, with the apex slightly recurved, and the base more or less obscurely notched before and behind. The canines (*c*) are very little longer than the false molars. The incisors (*i*) are minute, slightly compressed, and pointed; they are separated from each other and the canines by wide intervals.

Fig. 74.

Dentition of the Myrmecobius.

Amphitherium.

The genus Amphitherium is founded on fossil remains of lower jaws and teeth discovered, like those of the Phascolothere, in the oolitic slate at Stonesfield, in Oxfordshire, and it receives elucidation from the dental characters of the previous genus, but is remarkable for having a still greater number of molar teeth. The dental formula is as follows:—

$$i\,\frac{??}{3.3};\ c\,\frac{??}{1.1};\ p\,\frac{??}{6.6};\ m\,\frac{??}{6.6}.$$

There being thus thirty-two teeth in the lower jaw, and probably as many in the upper jaw. The incisors (fig. 75, *i*) are small, simple,

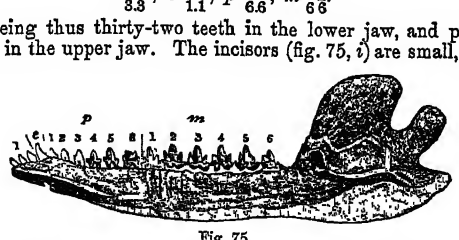


Fig. 75.

Lower Jaw and Teeth of the Amphitherium. Twice nat. size.

and separated by intervals, as in the existing Marsupial genus *Myrmecobius*; the canine (*c*) had a similar form. The shape of the crowns of the premolars (*p*) and molars (*m*) is shewn in the specimens of the larger species (*Amphitherium Broderipii*), in the museum at York, their implantation of the jaw, each by two long slender roots, as indicated in *m* 1 and 2, is demonstrated by one of the specimens of the smaller species (*Amphitherium Prevostii*) in the museum at Oxford.

Teeth of Mammals.

The singular animal on which this genus was founded, has but two toes on each fore foot; its dental formula is—

Choeropus.

$$i\,\frac{4.4}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{4.4}{4.4} = 46.$$

All the teeth are of small size; the upper incisors are conical, the lower ones truncated, and the hindmost is notched; the canines are conical and compressed; the upper one is simple and remote from the incisors; the lower one is near the incisors, and is notched anteriorly; the premolars are separated by intervals, as in *Myrmecobius;* they are tricuspid, except the first in the upper jaw, which resembles the canine. Each true molar consists of two triangular prisms, those of the upper jaw being broader than those below, and with their base turned outwards, contrary to those in the lower jaw. The genus would seem by its dentition to rank between *Myrmecobius* and *Perameles*. Its digital characters are anomalous and unique among the Marsupialia, but are evidently a degeneration from the Saltatorial or Bandicoot type.

Didelphys.

The dental formula of the genus *Didelphys* is—

$$i\,\frac{5.5}{4.4};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{4.4}{4.4}:\ 50\ \text{(Fig. 76).}$$

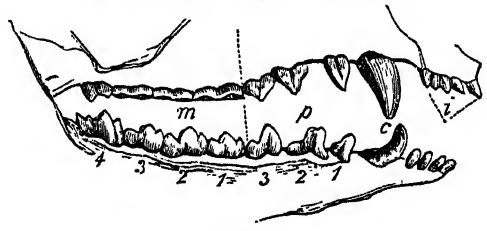


Fig. 76.

Dentition of the Virginian Opossum.

The Opossums resemble in their dentition the Bandicoots more than the Dasyures; but they closely resemble the latter in the tuberculous structure of the molars, the two middle incisors of the upper jaw are more produced than the others, from which they are also separated by a short interspace.

The canines still exhibit a superior development in both jaws adapted for the destruction of living prey, but the molars have a conformation different from that which characterizes the true flesh-feeders, and the Opossums consequently subsist on a mixed diet, or prey upon the lower organized animals.

The smaller species of *Didelphys*, which are the most numerous, fulfil in South America the office of the insectivorous Shrews of the old continent. The larger Opossums resemble in their habits, as in their dentition, the carnivorous Dasyures, and prey upon the smaller quadrupeds and birds; but they have a more omnivorous diet, feeding on reptiles and insects, and even fruits. One large species (*Did. Cancrivora*) prowls about the sea-shore, and lives, as its name implies, on crabs and other crustaceous animals. Another species, the Yapock, frequents the fresh water, and preys almost exclusively on fish. It has all the habits of the Otter; and, in consequence of the modifications of its feet, forms the type of the sub-genus *Chironectes*, Ill. Its dentition, however, does not differ from that of the ordinary Opossums.

Tarsipes.

The dental formula of the genus *Tarsipes* has not been accurately determined; the molars soon begin to fall; the small canines are also deciduous; the two procumbent incisors of the lower jaw remain the longest. The inferior incisors are opposed to six minute incisors above, which are succeeded by a small canine and some small molars; but these are reduced in some, perhaps old individuals, to a single tooth on each side.

Phalangista.

The Phalangers, being provided with hinder hands and prehensile tails, are strictly arboreal animals, and have a close external resemblance to the Opossums, by which name they are generally known in Australia and the islands of the Indian Archipelago, where alone they have hitherto been found. They differ from the Opossums chiefly in their dentition, and in accordance with this difference, their diet is more decidedly of a vegetable kind.

Phascolarctos.

The absence of anomalous or functionless premolars, and of inferior canines, appears to be constant in this genus, the dental formula of which, in other respects resembles that of *Phalangista;* it is—

$$i\,\frac{3.3}{1.1};\ c\,\frac{1.1}{0.0};\ p\,\frac{1.1}{1.1};\ m\,\frac{4.4}{4.4} = 30\ \text{(Fig. 77).}$$

The true molars (fig. 77) are larger in proportion than in the Phalangers; each is beset with four three-sided pyramids (*a*, *b*, *c*, *d*), the cusps of which wear down in age, the outer series in the upper

[1] *Transactions of the Geological Society of London*, vol. vi. 2d series, 1838, p. 58, pl. 6.

Teeth of Mammals.

teeth being the first to give way; those in the lower jaw are narrower than in the upper; there is also the rudiment of a "cingulum,"

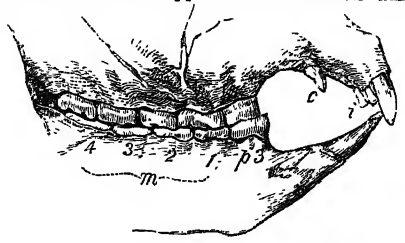
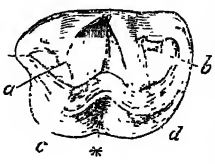


Fig. 77.
Dentition of the Koala (*Phascolarctos fuscus.*)



Molar Tooth of the Koala magnified.

as at **. The premolars (*p* 3) are compressed, and terminate in a cutting edge; in those of the upper jaw there is a small parallel ridge along the inner side of the base. The canine (*c*) slightly exceeds in size the posterior incisor, and terminates in an oblique cutting edge rather than in a point; the fang is closed at the extremity; it is situated, as in the Phalangers, close to the premaxillary suture. The lateral incisors of the upper jaw are small and obtuse; the two anterior or middle incisors are more than twice as large as the rest; they are conical, slightly curved, sub-compressed, bevelled off obliquely to the anterior cutting edge, but differing essentially from the *dentes scalprarii* of the Rodentia in being closed at the extremity of the fang. The two incisors of the lower jaw resemble those of the upper, but are longer and more compressed.

Hypsiprymnus.

The dental formula of *Hypsiprymnus*, the generic name of the Potoroos, or Kangaroo-rats, is—

$$i\frac{3.3}{1.1};\ c\frac{1.1}{0.0};\ p\frac{1.1}{1.1};\ m\frac{4.4}{4.4}=30$$

The anterior of the upper incisors, (fig. 78, *i*) are longer and more curved than the lateral ones, and their pulps are persistent. The canine (*c*) is larger than in the Koala; it is situated on the line of the premaxillary suture; and while the fang is lodged in the maxillary, the crown projects almost wholly from the premaxillary bone. In the large *Hypsiprymnus ursinus*, the canines are relatively smaller than in the other Potoroos, a structure which indicates the transition from the Potoroo to the Kangaroo genus. The single premolar (fig. 78, *p*) has a peculiar trenchant form; its maximum of development is attained in the arboreal Potoroos of New Guinea (*Hypsiprymnus ursinus* and *Hyps. dorcocepephalus*), in the latter of which its antero-posterior extent nearly equals that of the three succeeding molar teeth. In all the Potoroos, the trenchant spurious molar (*p*) is indented, especially on the outer side, and in young teeth, by many small vertical grooves. The true molars (*m* 1, 2, 3, 4) each present four three-sided pyramidal cusps; but the internal angles of the two opposite cusps are continued into each other across the tooth, forming two angular or concave transverse ridges. In the old animal these cusps and ridges disappear, and the grinding surface is worn quite flat.

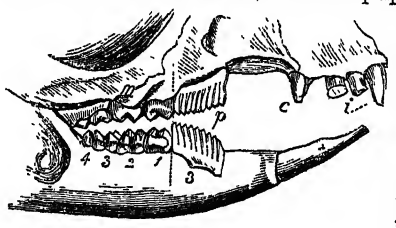


Fig. 78.
Dentition of the Potoroo, (*Hypsiprymnus.*)

In the genus Macropus (fig. 143), the normal condition of the permanent teeth may be expressed as follows:—

$$i\frac{3.3}{1.1};\ c\frac{0.0}{0.0};\ p\frac{1.1}{1.1};\ m\frac{4.4}{4.4}=28.$$

The main difference, as compared with *Hypsiprymnus*, lies in the absence of the upper canines as functional teeth; but the germs of these teeth are always to be found in the young mammary fœtus of the *Macropus major*, and the writer has detected them, but of very small size, and concealed by the gum, in the adults of some small species of Kangaroos, as, *e.g.*, *Macropus rufiventer*, Ogilby, and *Macr. psilopus*, Gould. This, however, is a rare exception; while the constant presence and conspicuous size of the canines will always serve to distinguish the Potoroo from the Kangaroo. The crown of the true molars supports two principal transverse ridges, with a broad anterior talon and a narrow hinder one. In most species a spur is continued from the hinder to the fore ridge, and another from the fore ridge to the front talon.

Dr Mason Good has remarked, "The *Mus maritimus*, or African rat, has the singular property of separating at pleasure, to a considerable distance, the two front teeth of the lower jaw, which are not less than an inch and a quarter long; that elegant and extraordinary creature, the Kangaroo, which, from the increase that has lately taken place in his Majesty's garden at Kew, we may soon hope to see naturalized in our own country, is possessed of a similar faculty."[1]

Teeth of Mammals.

This faculty of divaricating the lower incisors is due to the laxity of the symphysial union of the two rami of the lower jaw; the teeth merely move with the bones in which they are implanted. Remains of gigantic Kangaroos have been discovered in the same caves in Australia which contained the teeth and jaws of the large extinct *Dasyurus laniarius*, and they probably formed the prey of that species and of its contemporary the Thylacine, which has equally become extinct in the continent of Australia.

Diprotodon.

A gigantic extinct herbivorous Australian Marsupial, the bulk of which may be surmised from the length of the skull, which equals three feet, manifests a dentition which makes the nearest approach to the type of the Kangaroos; but the anterior or median pair of upper incisors of the upper jaw present the condition of large, curved, scalpriform, over-growing tusks, which work against a similar but straight procumbent pair of incisive tusks below; thus presenting a transitional feature between the Kangaroos and the Rodent form of Marsupial called Wombat (*Phascolomys*).

By reason of this modification, the writer separated the above large fossil Marsupial generically from Macropus, and proposed for it the name of Diprotodon, or two-incisored, in his Description of the Australian fossil Mammalia, in the appendix to "Mitchell's Expedition into the Interior of Eastern Australia," 8vo, 1838.

He has since ascertained that the second and third incisors are present, though of diminutive size, in the upper jaw of the Diprotodon; but as these teeth are actually reduced to two in the lower jaw, and functionally so in the upper one, the generic name is still applicable. There is no trace of canines in either jaw. The molars present the double transversely-ridged type of the Macropus, an anterior and posterior low basal ridge being added to the two principal eminences.

Five such molars were developed on each side of both jaws, progressively increasing in size from the first to the fourth. The first is generally shed before the last is in place.

A second genus of huge Marsupial Herbivora has been indicated under the name of *Nototherium*.[2] The *Thylacoleo* seems to have been designed to keep these giants of the order in check.

Phascolomys.

The dental system presents, in fig. 79, the extreme degree of

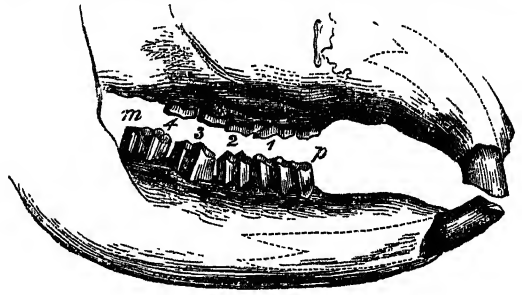


Fig. 79.
Dentition of the Wombat (*Phascolomys*).

that degradation of the teeth, intermediate between the front incisors and true molars, which has been traced from the Opossum to the Kangaroos; not only have the functionless premolars and canines now totally disappeared, but also the posterior incisors of the upper jaw, which we have seen in the Koala and Potoroo to exhibit a feeble degree of development as compared with the anterior pair; these, in fact, are alone retained in the dentition of the genus *Phascolomys*.

The dental formula of the Wombat is thus reduced, both in number and kind, to that of the true Rodentia, viz.—

$$i\frac{2}{2};\ c\frac{0}{0};\ p\frac{1.1}{1.1};\ m\frac{4.4}{4.4}=24\ \text{(Fig. 79)}.$$

The incisors (*i*), moreover, are *dentes scalprarii*, with persistent pulps; but are inferior, especially in the lower jaw, in their relative length and curvature to those of the placental *Glires;* they present a subtriedral figure, and are traversed by a shallow groove on their mesial surface. The premolars (*p*) present no trace of that compressed structure which characterises them in the Koala and Kangaroos, but have a wide oval transverse section; those of the upper jaw being traversed, on the minor side, by a longitudinal groove. The true molars (*m* 1-4) are double the size of the premolars; the superior ones are also traversed by an internal longitudinal groove; but this is so deep and wide that it divides the whole tooth into two prismatic portions, with one of the angles directed inwards. The inferior molars are in like manner divided into two triedral portions, but the intervening groove is here external, and one of the facets of each prism is turned inwards. All the grinders are curved, and describe about a quarter of a circle. In the upper jaw the concavity of the curve is directed outwards; in the lower jaw, inwards. The false and true molars, like the incisors, have persistent pulps, and

[1] *Book of Nature*, vol. i. p. 285. 1826.

[2] Owen, *Report on the Extinct Mammals of Australia, &c.* 8vo, 1844, p. 12.

Teeth of Mammals.

are, consequently, devoid of true fangs, in which respect the Wombat differs from all other Marsupials, and resembles the extinct *Toxodon*, the dentigerous *Bruta*, and herbivorous *Rodentia*.

The cuts, figs. 72, 70, 77, and 80, showing the working surface of the molar teeth, exemplify stages in the progressive transition from the carnivorous to the herbivorous modification of those teeth in the Marsupial series.

Figure 72, nat. size, is the lower carnassial tooth of the great extinct *Thylacoleo*. Fig. 70 is an upper molar of the largest existing Marsupial carnivore, the Thylacine of Tasmania; the addition of the inner lobe (*c*) gives it a triangular form. In the *Dasyurus* the inner lobe is augmented, and the outer division is thickened by the development of a pointed tubercle or cusp from the cingulum. In the Bandicoot (*Perameles Myosuros*), a second lobe answering to *d* in fig. 77 is added to the inner division of the crown, and two tubercles are developed from the outer part of the cingulum; in the *Phalangista* and Koala (fig. 77), the outer tubercles are obsolete, and the principal lobes (*a*, *b*, *c*, *d*) are almost equal, with a posterior basal ridge and the rudiment of an anterior one. In the *Hypsiprymnus* the lobes answering to *a* and *c* begin to coalesce and form a transverse ridge, as do those behind answering to *b* and *d*. In the Macropus (fig. 143) the coalescence is more complete; and in the *Diprotodon* the double cross-ridged structure is complete. The parts of the cingulum forming the anterior and posterior basal ridges are present in all the three last examples. Finally, the Wombat (fig. 80) shows the most aberrant modification of the grinding surface. The cut is taken from a molar tooth of the lower jaw of the great extinct *Phascolomys gigas*.

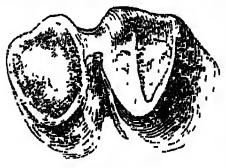


Fig. 80.

Grinding Surface of a Lower Molar (nat. size) of the Great extinct Wombat.

Order Insectivora.

The dental system in this order is remarkable for the many varieties and even anomalies which it presents—almost the only characteristic predicable of it in the numerous small quadrupeds which constitute it being the presence of several sharp points or cusps upon the crowns of the molar teeth, which are always broader in the upper than in the lower jaw. The teeth that intervene between these and the incisors are most variable in form and size, but are never absent; the incisors also differ in number, size, and shape, in different species, the anterior ones approximating in some species to the character of the scalpriform teeth of the Rodents.

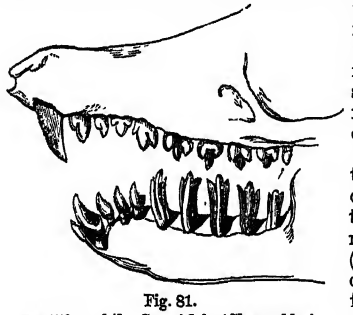


Fig. 81.

Dentition of the Cape-Mole (*Chrysochloris capensis*) magnified.

Chrysochloris.

Of all existing *Insectivora*, the Chrysochlore, or iridescent mole of the Cape, makes the nearest approach, by the number of its molar teeth (fig. 81), to that remarkable condition which was manifested in the most ancient period of Mammalian existence by the extinct *Amphitherium* and *Spalacotherium* of the Oolitic period in geology. At least $\frac{5}{5}:\frac{6}{6}$ true molars may be assigned to the Chrysochlore according to their form—the only character, in the absence of the known order of vertical displacement and succession by which the true and false molars can at present be defined in this species. The anterior large laniariform tooth, and the two succeeding small teeth, are incisors, by virtue of their position in the premaxillary bones; the next small tooth, with a simple compressed tricuspid crown, may be regarded either as a canine or a premolar. The crowns of the true molars are thin plates, flattened from before backwards, with two notches on the working edge, and a longitudinal groove along the outer and thicker margin. Another anomaly, more remarkable than that of the shape of the true molars, is their separation from each other by vacant intervals, as in many Reptiles.

The crowns of the five lower true molars are compressed anteroposteriorly, but are of unusual length, and have the thicker margin turned inwards; the summit of the outer border is pointed and most prominent; the inner division is subdivided into two points. The anterior incisor is small and procumbent; the second has a larger laniariform crown; the third is small, and resembles the two premolars which intervene between this and the first large tricuspid molar. The lower molars are separated by wider intervals than those above; the crowns of the opposing series enter reciprocally the interspaces, and interlock; in mastication, the anterior margin of the lower tooth works upon the posterior margin of the opposite upper tooth.

Teeth of Mammals.

According to M. Cuvier,[1] each series in the upper jaw of the Chrysochlore includes one incisor and nine molars; and in the lower jaw two incisors and eight molars. M. de Blainville, guided by the intermaxillary sutures in the young Chrysochlore, regards the first three teeth in each lateral series as incisors, the fourth as a canine, and the remaining six as molars in both upper and lower jaws. The writer's views, as given in the foregoing description, are expressed by the following formula:—

$$i\,\frac{3.3}{3\,3};\quad p\,\frac{1.1}{2\,2};\quad m\,\frac{6\,6}{5\,5}=40.$$

Spalacotherium.

The small insectivorous mammal, called *Spalacotherium*,[2] which has left its fossil remains in the upper Oolite of Purbeck, had ten molar teeth on each side of the lower jaw, of which six at least presented a tricuspid crown (fig. 82), with proportions very similar to those of the Chrysochlore.

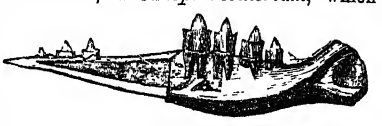


Fig. 82.

Part of Lower Jaw and Teeth of the *Spalacotherium tricuspidens*.

Scalops.

In the Shrew-moles of America (*Scalops*) the dentition makes an important step towards the normal mammalian condition, by the restriction of the characters of the true molar teeth to the three posterior ones in each lateral series; between these and the large scalpriform incisor, in the upper jaw, there are six teeth; the first two of which must also be regarded, by the analogy of the Chrysochlore, as incisors; the next tooth might pass for a canine; and the remaining three for premolars; of these the last is the largest, and has a triedral pointed crown. The true molars have large crowns, each with six cusps, four on the outer, and two on the inner part of the grinding surface. In the lower jaw the first incisor is small and procumbent, and the second large and laniariform, as in the Chrysochlore; the third is absent, and a vacant space separates the incisors from the three premolars, and the crown of each true molar consists of two parallel three-sided prisms, each terminated by three cusps, and having one of the angles turned outwards, and one of the faces inwards; the interspaces between the angles makes the outer surface of the long molars of the *Scalops* appear grooved. The dental formula of this genus, according to the above description, is—

$$i\,\frac{3\,3}{2\,2};\quad c\,\frac{1.1}{0.0};\quad p\,\frac{3.3}{3.3};\quad m\,\frac{3\,3}{3\,3}=36.$$

Talpa.

The dentition of the common mole (*Talpa europæa*. fig. 83) includes eleven teeth on each side of both upper and lower jaws. The first three in the upper jaw are very small, with simple incisive crowns, and are each implanted by a long and slender fang. These teeth are incisors. The next tooth (*c*), by the size and shape of the crown, represents a canine, but it is implanted by two fangs like the succeeding premolar teeth. Three of these teeth (*p* 1, 2, 3) are of small size, with compressed conical crowns; the fourth premolar (*p* 4) has a larger three-sided conical crown, supported by three fangs, the crowns of the true molars (*m* 1, 2, 3) are multicuspid; the middle one the largest, with five points, and usually supported by four fangs, the hindmost the smallest, with a tricuspid crown and three fangs. In the lower jaw the first four teeth on each side are small, simple, and single-fanged, like the three incisors above; the fifth tooth has a large laniariform crown, supported by two fangs, being very similar to, but shorter than, the two-fanged canine above. As it passes behind that tooth when the mouth is shut, we must regard the fourth tooth below, notwithstanding its small size and similarity to the incisors, as the true inferior canine, as it is in the Ruminants. The fifth tooth (*p* 1) is then the first and largest of the series of four premolars, each of which has a small posterior talon at the base of the compressed conical crown. The three true molars (*m* 1, 2, 3) are each implanted by two fangs, and have quinque-cuspid crowns, the middle molar being the largest.

Fig. 83.

Dentition of the Mole (*Talpa europæa*).

The teeth of the mole have been differently classified by different authors; but the difference turns mainly upon the determination of the canine teeth. F. Cuvier[3] and T. Bell[4] both regard the fourth large tooth of the upper jaw (*c*) as a canine, notwithstanding it has two fangs. M. de Blainville[5] describes it as an incisor, in which case the double implantation would be still more anomalous. The position of the incisive foramen, however, indicates that the double socket of this tooth is posterior to the premaxillary suture, and that the number of incisors has been rightly determined by F. Cuvier.

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[1] *Dents de Mammiferes*, p. 63. [2] *Proceedings of the Geological Society*, June 1854, p. 426. [3] *Dents de Mammiferes*, p. 62.
[4] *History of British Quadrupeds*, 8vo, 1837, p. 85. [5] *Osteographie, Insectivores*, 4to, p. 49.

Teeth of Mammals.

By this justly-esteemed authority, the canines are held to be wanting in the lower jaw of the mole. Mr Bell regards as lower canines the large fifth tooth on each side, although posterior to the canine above; and M. de Blainville, having assigned eight incisors to the upper jaw, adopts the same view in regard to the lower jaw, and calls the first premolar (p 1) a canine. With regard to the fourth tooth above, if it be not developed in the premaxillary bone, it claims to be regarded as a canine by the size and shape of the crown, and to be a premolar by virtue of its two fangs; but, since the fang of a tooth is subject to more variety than the crown, the present writer has been guided by the more fixed character, and has called the tooth in question a canine.[1] The fourth tooth below (c), although so small, is the only one which has the true relative position of a canine, in advance of the one above when the mouth is shut, and we shall find in the genus *Lemur* a similar conformity of size and shape between the lower canine and incisors as exists in the common mole.[2] There is no difficulty about the other teeth, the canines being determined, and thus the dental formula of the genus *Talpa* is—

$$i\,\tfrac{3.3}{3.3};\ c\,\tfrac{1.1}{1.1};\ p\,\tfrac{4.4}{4.4};\ m\,\tfrac{3.3}{3.3} = 44.$$

According to this homology, the teeth are equal in number, and alike in kind in both jaws; the true molars are reduced to the normal quantity in the placental series, and the entire dentition is the least anomalous of any which is manifested in the family *Talpidæ*.

In the *Talpa moogura*, *Temm*, the inferior canine is absent, as in the genus *Scalops*. In the *Condylure*, or Rayed-mole, it is present, with the form and proportions of a canine.

In *Talpa leucura*, Blyth (p 1), is wanting.

Soricidæ. Solenodon.

The transition from the Moles to the Shrews seems to be made by the water-moles (*Mygale*), and the *Solenodon*. The latter insectivore combines the form of a gigantic Shrew, with a dentition resembling that of the Chrysochlore. Each premaxillary bone contains three incisors, the first large, canine-shaped, grooved anteriorly, with the point inclined backwards; the other two incisors small, with simple conical crowns; these are succeeded by seven teeth, the two anterior having three-sided conical crowns, the other five bearing, in addition, an external tuberculate basal ridge In the lower jaw, the anterior incisor is very small, and the second large and laniariform, as in the Scalops and Chrysochlore; but it is remarkable for a deep longitudinal excavation upon its inner side,[3] apparently produced by the friction of the large upper incisors which are received into the interspace of the lower pair; the third lower incisor is small and simple; of the seven succeeding teeth, the four last have multicuspid crowns like true molars.

Mygale.

The Pyrenean Water-mole (*Mygale pyrenaica*) has eleven teeth on each side of both jaws; the first incisor above is relatively larger than in *Scalops*, trihedral, and sharp-pointed; the second and third incisors are very small; none of the succeeding teeth present the form and size of a canine; the last three teeth are multicuspid, and are true molars. In the lower jaw, all the teeth anterior to the true molars are small and simple.

The teeth in the lower jaw of a species of Water-mole (*Palæospalax*), as large as a Hedgehog, which has become extinct in England, present a close resemblance with those of the *Mygale;* the true molars have square, quinque-cuspid crowns, but are distinguished from the teeth of all known recent *Insectivora* by the presence of a minute tubercle at the bottom of the outer vertical fissure of the crown.[4]

The typical Shrews always manifest their rodent analogy by the great preponderance of the anterior pair of incisors in both upper and lower jaws. In the lower jaw the great incisor is uniformly succeeded by two small and three large multicuspid molars; but in the upper jaw the number of small premolars varies. The last true molar is commonly of small size. The subgenera of Shrews are chiefly based upon the form of the large incisors and the numerical variations of the dentition of the upper jaw. In the common Shrew (*Sorex araneus* of Linnæus) there are four true molars and three small teeth between these and the anterior incisor; this tooth has a pointed tubercle at the back of the base of the crown. The long procumbent incisor of the lower jaw has the trenchant superior margin entire. In the *Sorex* (*Amphisorex*) *tetragonurus*, the upper edge of the lower incisor is notched; the large upper incisor appears bifurcate from the great development of the posterior talon; five small teeth, progressively decreasing in size, intervene between the upper large incisor and the true molars. In the *Sorex* (*Hydrosorex*) *Hermanni*, the trenchant edge of the lower procumbent incisor is entire; there are four small teeth between the large anterior incisor and the true molars in the upper jaw, as in the great *Sorex indicus*; but the three first are subequal, and the fourth very minute; there is a fourth small true molar above. The enamelled tips of the teeth of the species of *Amphisorex* and *Hydrosorex* are stained of a bright brown colour; the teeth of *Sorex* proper, as the common Shrew (*S. araneus*), are not so stained.

Teeth of Mammals.

In the progress of the formation of the large notched incisors, the summits of the tubercles are first formed as detached points, supported upon the common pulp, and do not become united until the centripetal calcification has converted this into a common dentinal base. Some anatomists have regarded the large incisor so formed as an aggregate of two or three teeth; but in *Sorex* proper and *Hydrosorex*, the calcification of the lower incisor spreads from a single point, and the interpretation of the notched incisor of the *Amphisorex*,[5] as the representative of these incisors, might, by parity of reasoning, be applied to the human incisor teeth, the dentated margins of which are likewise originally three or four separate tubercles.

The determination of the small teeth between the large anterior incisors and the multicuspid molars depends upon the extent of the early anchylosed premaxillaries; the incisors being defined by their implantation in those bones, the succeeding small and simple-crowned molars must be regarded as premolars; not any of them having the development or office of a canine tooth; their homotypes in the lower jaw are implanted by two roots.

The thickness of the enamel, in proportion to the body of dentine, is unusually great in these small insectivores, and the sharp points of the teeth long retain their fitness for the office of cracking and crushing the hard or tough teguments of insects.[6] The enamel-pulp of the large lower incisors is so large as to overlap, in the young Shrew, the growing margin of the socket, so as to encase with enamel not only the crown of the tooth, but also the contiguous part of the jaw-bone. Daubenton first drew attention to this structure, and M. Duvernoy has likewise made the interesting observation, that the roots of the teeth of Shrews become anchylosed to the jaw-bone, a reptilian character offered by the *Sorricidæ* alone in the mammalian class.

Erinaceidæ. Glisorex.

In the dentition of the Tupaias (*Glisorex*) we begin to trace characters intermediate between those of the dentition of Shrews and of Hedgehogs. The dental formula of the *Glisorex tana* is—

$$i\,\tfrac{2.2}{2.2};\ c\,\tfrac{1.1}{1.1};\ p\,\tfrac{3.3}{3.3};\ m\,\tfrac{3.3}{3.3} = 36.$$

The upper incisors are small, simple, and wide apart in the upper jaw; the anterior incisor in the lower jaw is long and procumbent, but relatively smaller than in the Shrews; the canines are small in both jaws; the premolars increase in size and complexity as they approach the true molars; the first two of these are subequal, with six cusps in the upper and five cusps in the lower jaw; the last true molar is smaller, and is tricuspid.

Gymnura.

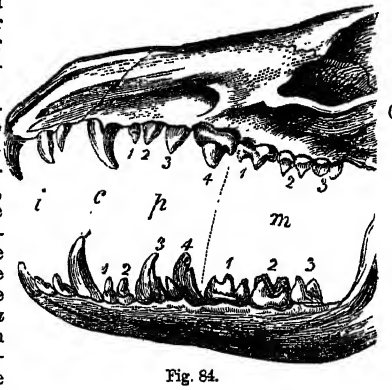

Fig. 84.

Dentition of the *Gymnuria Raffiesii*.

In *Macroscelis* (Elephant-mice of the Cape) and *Gymnura*, each intermaxillary bone contains three teeth, which, in the former genus, are succeeded by four premolars and three true molars, with the same number of teeth in the lower jaw. In *Gymnura* (fig. 84) the first tooth which succeeds the incisors has the form and size of a canine (c) in both upper and lower jaws, but has two roots in the upper jaw; this is followed by four premolars (p 1-4), the last of which, in the upper jaw, is large and quadricuspid, the first (m 1) and second (m 2) of the true molars have square multicuspid crowns; the last true molar (m 3) is smaller and triangular. In the lower jaw of the *Gymnura* the fourth premolar (p 4) has a compressed tricuspid crown. The dental formula of *Gymnura* is typical, viz.—

$$i\,\tfrac{3.3}{3.3};\ c\,\tfrac{1.1}{1.1};\ p\,\tfrac{4.4}{4.4};\ m\,\tfrac{4.4}{4.4} = 42.$$

Erinaceus.

The dentition of our common Hedgehog (*Erinaceus europæus*) shows greater inequality in the upper and lower jaws, the formul being—

$$i\,\tfrac{3.3}{3.3};\ p\,\tfrac{4.4}{2.2};\ m\,\tfrac{3.3}{3.3} = 36.$$

[1] *Odontography*, 1842, p. 416. Mr Blyth has arrived, as it seems independently, at the same conclusion. He writes: "In the moles, as in most other Insectivora, and also in the *Lemuridæ*, the lower canine is minute, and takes the form of an incisor, for which it has been very commonly mistaken, and the first premolar is developed to assume the form of a canine."—*Journal of the Asiatic Society*, No. 3, 1850.

[2] See *Brandt, Acta Petropol*, ii. 1834.

[3] The name of the genus (σόλην, a pipe, ὀδους, a tooth, relates to this structure.)

[4] *History of British Fossil Mammals*, p. 25.

[5] See the beautiful monograph *Sur les musaraignes*, by Professor Duvernoy, in the *Memoires de la Societé d' Histoire Naturelle de Strasbourg*, 1834.

[6] See De Blainville, *Osteographie des Insectivores*, p. 55

Teeth of Mammals.

The first incisor in both upper and lower jaws is larger and longer than the rest, and is very deeply implanted in the jaw; the tooth which follows the incisors is small in both jaws, but especially so in the lower; it has two roots in the upper jaw. The last premolar is the largest in both jaws; above it has a quadricuspid crown with three fangs; below, a subcompressed tricuspid crown with two fangs. The true molars decrease in size from the first to the third in both jaws, the first and second have subquadrate four-pointed crowns above; below, they are narrower, and the anterior and inner angle is produced into a fifth cusp.

The true molars of the tropical Hedgehogs, forming the sub-genera *Echinops* and *Ericulus*, are more simple, and approach the form of those in the Chrysochlore, being compressed from before backwards, with two outer cusps and one inner cusp in the upper jaw, and with one outer and two inner cusps in the lower jaw. The number of incisors is $\frac{2}{2}:\frac{2}{2}$ in both sub-genera, which are followed by $\frac{2}{2}:\frac{2}{2}$ small and simple premolars; but *Ericulus* has $\frac{5}{5}:\frac{5}{5}$ compressed tricuspid molars, and *Echinops* only $\frac{4}{4}:\frac{4}{4}$.[1]

Centetes.

The large Tenrecs or tailless Hedgehogs of Madagascar, combine the simple molars of the *Ericulus* with the most formidably developed canines which are to be met with in the whole order *Insectivora*. The incisors are two in number in the upper jaw, but three in the lower jaw; very small and sub-equal in both; the canines are long and large, compressed, trenchant, sharp-pointed, recurved, and single-fanged, thus presenting all the typical characters of those teeth in the *Carnivora*. They are separated in both jaws by a wide space from the premolars; the first above is compressed, unicuspid with a hinder talon, and two-fanged; the second has a larger prismatic tricuspid crown and three fangs; of the four posterior teeth, which by their antero-posterior compression may be regarded as true molars, the first three have tricuspid crowns as in the *Echinops*, and have three fangs; the fourth is smaller, is tricuspid, and has two fangs; all the lower molars have two fangs.

Structure.

The teeth of the insectivora consist of a basis of hard dentine, with a thick coronal investment of enamel, and an outer covering of cement, very recognizable in the interspaces of the coronal cusps, in microscropic sections of the molars of the larger species, as the Tenrecs and Macroscelles, and always thick where it closes the extremity of the fangs. Here the cement is commonly more highly organized, is traversed by medullary canals, generally presenting concentric walls, thus assumes the character of true bone, and, in the *Soricidæ*, is frequently continued into the substance of the jaw itself.

The small proportion of dentine, in comparison with the thick layer of enamel, has been already alluded to in the Shrews, yet the dentinal tubuli are at their commencement very little inferior in diameter to those of the human incisors; the trunks are very short, and are resolved into radiated penicilli of undulating branches, which quickly subdivide, interlace and anastomose together near the boundary line between the dentine and enamel. In most of the *Insectivora*, the secondary branches of the dentinal tubes are unusually conspicuous, especially in the dentine forming the fangs. The dentinal compartments are rarely well defined; in the large canines of the *Centetes*, they are sub-hexagonal, and about $\frac{1}{8000}$th of an inch in diameter, but diminish in size towards the periphery of the dentine.

Development.

The deciduous teeth of the Moles and Shrews are uterine, *i. e.*, are developed, and disappear before birth. They are extremely small, and are all of the most simple form. In the fœtal *Sorex araneus*, calcification of the papillary exposed pulps of the teeth, which are succeeded by the first and second premolars, proceed to a very slight extent, and these microscopic rudiments appear to be absorbed rather than shed. The deciduous incisors are further advanced before their displacement, and present the form of equal-sized dentinal spicula, tipped with enamel, attached by the opposite end to the gum, and not exceeding $\frac{1}{40}$th of an inch in length; the number of the uterine series of teeth is $\frac{4.4}{3.3}$.

Order Cheiroptera.

In the volant *Insectivora*, or Bats, the canines are always present in both jaws, of the normal form, and with slightly variable proportions. The molar series never exceeds $\frac{6.6}{6.6}$, and is divisible into premolars and true molars; the latter are bristled, with sharp points, and this type characterises the great bulk of the *Cheiroptera* of Cuvier. The molars of the large frugivorous Bats (*Pteropus*) have flat crowns.

The incisors are the most variable teeth in the *Cheiroptera;* they may be entirely wanting, or be present in the numbers of 1.1 to 2.2 in the upper, and from 1.1 to 3.3 in the lower jaw; they are always very small, and, in the upper jaw, commonly unequal, and separated by a wide median vacancy. In the genus *Chilonycteris*, the mid-incisors above, and the outer ones below, have the crown notched; the mid-incisors below have two notches, producing three lobes on the cutting border. Taking the common simple-nosed Bat (*Vespertilio murinus*) as a type of this Insectivorous group, we find its dental formula to be— Teeth of Mammals.

$$i\,\frac{2.2}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3} = 38.$$

The dentition of the suctorial or Vampire Bats deviates, as might be anticipated, in a remarkable degree from that of the Insectivorous Bats. The crushing instruments required for the food of those species are not needed; and the true molars, with their bristled crowns, are entirely absent in the Vampires (*Desmodus*), (fig. 85). The teeth, at the fore-part of the mouth, are especially developed, and fashioned for the infliction of a deep and clean triangular puncture, like that made by a leech. The incisors are two in number above, closely approximated, one in each premaxillary bone, with a very large, compressed, curved, and sharp-pointed crown, implanted by a strong fang which extends into the maxillary bone. The upper canines have similar large lancet-shaped crowns, and their bases touch those of the incisors. In the lower jaw the incisors are two in number on each side, much smaller than the upper pair, and with bilobed crowns. The lower canines are nearly equal in size to those above, and have similar piercing trenchant crowns. The molar series is reduced above to two very small teeth, each with a simple compressed conical crown, implanted by a single fang. The first two molars below resemble those above; but they are followed by a third, which has a larger compressed and bilobed crown, implanted by two fangs. This tooth corresponds with the last premolar in the more normal genera of Insectivorous Bats. The dental formula of the true Vampire Bat (*Desmodus*), is thus reduced to— Desmodus.

Fig. 85.

Skull and Teeth of the Vampire-Bat (*Desmodus Vampirus*).

$$i\,\frac{1.1}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{3.3} = 20.$$

The opposite extreme which the aberrant varieties of the Cheiropterous dentition attain, is manifested in the great frugivorous Bats—sometimes, but erroneously, called Vampires—but which have never been met with in South America, the peculiar country of the true blood-sucking Bats. Pteropus.

The complex stomach of a *Pteropus* is described as that of a Vampyre Bat in the "Lectures of Comparative Anatomy," by Sir Everard Home, who thereupon infers that "the Vampyre Bat lives on the sweetest of vegetables," and that "all the stories related with so much confidence of its living on blood, and coming in the night to destroy people while asleep, are entirely fabulous," p. 160. But the blood-thirsty habits of the true Vampyres have been observed or experienced by more than one scientific traveller in South America. Dr Spix calls one of these Bats, which he discovered in Brazil, "*Sanguisuga crudelissima;*" and Mr Darwin has recorded the attack of another species which fastened upon the withers of his horse during a nocturnal bivouac in Chili.[2]

In some African *Pteropi* (*Pt. macrocephalus* and *Pt. Whitei*), the last small molar would seem to be wanting in both upper and lower jaws, according to Messrs Ogilby and Bennett.[3]

The frugivorous species, sometimes called "flying foxes," and by the French "Rousettes," include the largest animals of the order *Cheroptera*, and constitute the genus *Pteropus;* their dental formula is—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{3.3};\ m\,\frac{3.3}{3.3} = 34.$$

The deciduous teeth make their appearance above the gum in Bats, as in Shrews, before birth; but they attain a more completely developed state, and are retained until a short time after birth, when they are shed.

The Colugos (*Galeopithecus*) resemble the Bats in the great expanse of their parachute, formed by the fold of integument extending on each side from the fore to the hind extremity; but they appertain, by the essential characters of their organization, to the *Lemuridæ;* the dental formula of the genus is— Galeopithecus.

$$i\,\frac{2.2}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{2.2};\ m\,\frac{3.3}{3.3} = 34.$$

The two anterior incisors of the upper jaw are separated by a wide interspace; in the Philippine Colugo they are very small, with simple bilobed crowns; but in the common Colugo (*Lemur volans*, Linn; *Galeopithecus Temminckii*, Wat.) their crown is an expanded plate, with three or four tubercles; the second upper incisor, which is unquestionably supported by the intermaxillary bone, presents the peculiarity of an insertion by two fangs in both species of *Galeopithecus*.

In the lower jaw the crowns of the first two incisors present the

[1] See Mr Martin's Memoir in the *Zoological Transactions*, vol. ii.

[2] See *Voyages of the Adventure and Beagle*, vol. iii. p. 25.

[3] *Trans. Zool. Soc.* ii. p. 34.

Teeth of Mammals.

form of a comb, and are in this respect unique in the class *Mammalia;* one is figured magnified three diameters in cut 86. This singular form of tooth is produced by the deeper extension of the marginal notches on the crown, analogous to those on the edge of the new-formed human incisor; the notches being also more numerous as well as deeper; each of these teeth is implanted by a single conical fang.

Fig. 86.

Lower Incisor of *Galeopithecus.* Magn.

Structure.

In the broad pectinated incisors of the *Galeopithecus* the pulp-cavity divides at the base of the crown into as many canals as there are divisions of the crown, one being continued up the centre of each to within a short distance of its apical extremity. The dentinal tubes which radiate from these canals have a diameter at their origin of $\frac{1}{15,000}$th of an inch; they quickly divide and subdivide dichotomously, with rather large and irregular secondary undulations, sending off many fine branches, and resolving themselves into numerous smaller ramifications which interlace irregularly near the enamel.

Order Rodentia.

In different orders of the class *Mammalia*, there are instances in which the ordinary number of incisors is diminished, and their growing power transferred to a single pair of tusks projecting from the forepart of the upper or the lower jaw, or of both. The Dinotheres, Toxodons, Mastodons, and Elephants, among the *Ungulata*, the Dugong in the *Sirenia*, the Aye-aye in the *Quadrumana*, the Diprotodon and Wombat in the *Marsupialia*, and the Narwhal amongst the *Cetacea*, are instances of this modification; which reaches its extreme in the latter mammal in which the dentiparous force seems concentrated in a single tooth of the upper jaw, which acquires the shape of a long spiral horn.

But there is an extensive series of small *Mammalia* in which a single pair of large, curved, ever-growing incisors in each jaw is associated with so many other peculiarities of structure, as to have caused them to be regarded as a distinct order of the class, which Linnæus defined as the *Glires*, and which Cuvier called, from the habit associated with that dental modification, "Rongeurs," *Rodentia* or Gnawers. These incisors (fig. 87, *i*), separated by a wide interval from a short series of molars, characterize the whole order of Rodents; the single exceptional family, *Leporidæ*, including Hares, Rabbits, and Picas or tailless Hares of Siberia (fig. 90) retaining a second minute incisor (*i*, 2) behind each of the large ones in the upper jaw.

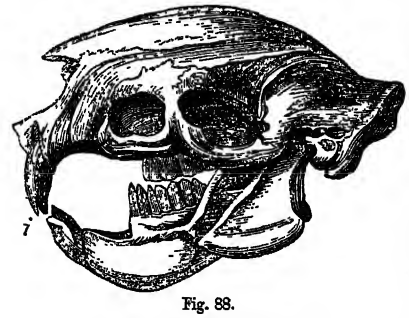

Fig. 88.

Skull and Teeth of a Porcupine.

The incisors are regularly curved, the upper ones (fig. 88, *i*) describing a larger segment of a smaller circle, the lower ones (fig. 21) a smaller segment of a larger circle; these are the longest incisors, and usually have their alveoli extended below, or on the inner side of those of the molars to the back part of the lower jaw (fig. 21, *i*). As in all teeth of unlimited growth, the implanted part of the incisors retains the form and size of the exposed part or crown, to the widely open base, which contains a long conical persistent dentinal pulp (fig. 21, *a*), and is surrounded by the capsule in a progressive state of ossification, as it approaches the crown, an enamel-pulp being attached to the inner side of that part of the capsule which covers the convex surface of the curved incisor. The matrix is here noticed in connection with the tooth, because it is always found in full development and activity to the time of the Rodent's death.

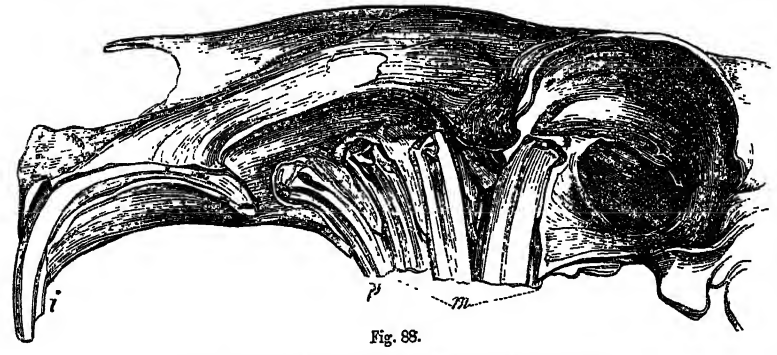

Fig. 88.

Cranium and Upper Teeth of the Patagonian Cavy (*Dolichitis*).

The calcification of the dentinal pulp, the deposition of the earthy salts in the cells of the enamel-pulp, and the ossification of the capsule, proceed contemporaneously; fresh materials being added to the base of the vascular matrix as its several constituents are progressively converted into the dental tissues in the more advanced part of the socket. The tooth, thence projecting, consists of a body of compact dentine, sometimes with a few short medullary canals continued into it from the persistent pulp-cavity, with a plate of enamel laid upon its anterior surface, and a general investment of cement, which is very thin upon the enamel, but less thin, in some Rodents, upon the posterior and lateral parts of the incisor. The substances of the incisor diminish in hardness from the front to the back part of the tooth, not only in so far as the enamel is harder than the dentine, but the enamel consists of two layers, of which the anterior and external is denser than the posterior layer, and the posterior half of the dentine is rendered by a modified number and arrangement of the dentinal tubes less dense than the anterior half.

Teeth of Mammals.

The abrasion resulting from the reciprocal action of the upper and lower incisors produces, accordingly, an oblique surface, sloping from a sharp anterior margin formed by the dense enamel, like that which slopes from the sharp edge formed by the plate of hard steel laid on the back of a chisel; whence the name "dentes scalprarii," given to the incisors of the Rodentia.

The varieties to which these incisors are subject in the different Rodents are limited to their proportional size, and to the colour and sculpturing of the anterior surface. Thus in the Guinea-pig, Jerboa, and Squirrel, the breadth of the incisors is not half so great as that of the molars; whilst in the Coypu they are as broad, and in the Cape Mole-rats (*Bathyergus* and *Orycteromys*), broader than the molars. In the Coypu, Beaver, Agouti, and some other Rodents, the enamelled surface of the incisors is of a bright orange or reddish-brown colour. In some genera of Rodents, as *Orycteromys*, *Otomys*, *Meriones*, *Girvilla*, *Hydrochœrus*, *Lepus*, and *Lagomys*, the anterior surface is indented by a deep longitudinal groove. This character seems not to influence the food or habits of the species; it is present in one genus and absent in another of the same natural family. In most Rodents the anterior enamelled surface of the scalpriform teeth is smooth and uniform.

The molar teeth are always few in number, obliquely implanted and obliquely abraded; the series in each side converging anteriorly in both jaws, but they present a striking contrast to the incisors in the range of their varieties, which are so numerous that they typify almost all the modifications of form and structure which are met with in the molar teeth of the omnivorous and herbivorous genera of other orders of mammalia.

In some Rodents—*e. g.*, Cavies (fig. 88), the molar teeth are rootless; others—*e. g.*, the Agouti, have short roots, tardily developed like the molars of the Horse and Elephant; others, again—*e.g.*, the Rat and the Porcupine, soon acquire roots of the ordinary proportional length.

The differences in the mode of implantation of the molar teeth relate to the differences of diet. The Rodents, which subsist on mixed food, and which betray a tendency to carnivorous habits, as, *e.g.*, the true Rats, or which subsist on the softer and more nutritious vegetable substances, such as the oily kernels of nuts, suffer less rapid abrasion of the molar teeth; a minor depth of the crown is therefore needed to perform the office of mastication during the brief period of existence allotted to these active little Mammals; and as the economy of nature is manifested in the smallest particulars as well as in her grandest operations, no more dental substance is developed after the crown is formed, than is requisite for the firm fixation of the tooth in the jaw.

Rodents that exclusively subsist on vegetable substances, especially the coarser and less nutritious kinds, as herbage, foliage, the bark and wood of trees, wear away more rapidly the grinding surface of the molar teeth; the crowns are therefore larger, and their growth continues by reproduction of the formative matrix at their base in proportion as its calcified constituents, forming the exposed working part of the tooth are worn away. So long as this reproductive force is active, the molar tooth is implanted, like the incisor, by a long undivided continuation of the crown. When the force begins to be exhausted the matrix is simplified by the suppression of the enamel-organ, and the dentinal pulp continues to be reproduced only at certain points of the base of the crown, which by their elongation constitute the fangs. The Beaver and other Rodents, in the second category of the order, according to the implantation of the molar teeth, exemplify the above condition. But in the Capybara, *Dolichotis* (fig. 88), and other Rodents with rootless molars, the reproduction of the grinders, like that of the incisors, appears to continue throughout the animal's existence. The rootless and perpetually growing molars are always more or less curved (fig. 88, *p*, *m*); they

derive from this form the same advantage as the incisors, in the relief of the delicate tissues of the active vascular matrix from the effects of the pressure which would otherwise have been transmitted more directly from the grinding surface to the growing base.

The complexity of the structure of the crown of the molar teeth, and the quantity of enamel and cement interblended with the dentine, are greatest in the rootless molars of the strictly herbivorous Rodents. The crowns of the rooted molars of the omnivorous Rats and Mice are almost as simple as the tuberculate molars of the Bear or of the human subject, which they appear to typify. They are at first tuberculate. When the summits of the tubercles are worn off, the inequality of the grinding surface is for a time maintained by the deeper transverse folds of enamel, the margins of which are separated by alternate valleys of dentine and cement; but these folds, sinking only to a slight depth, are in time obliterated, and the grinding surface is reduced to a smooth field of dentine, with a simple border of enamel. Examples of various forms assumed by the inflected folds of enamel in the molars of the *Rodentia* are given in the works of the Cuviers and other naturalists.[1] These folds have a general tendency to a transverse direction across the crown of the tooth. Baron Cuvier has pointed out the concomitant modification of the shape of the joint of the lower jaw, which almost restricts it to horizontal movements to and fro, in the direction of the axis of the head, during the act of mastication. When the folds of enamel dip in vertically from the summit to a greater or less depth into the substance of the crown of the tooth, as in those molars which have roots, the configuration of the grinding surface varies with the degree of abrasion; but in the rootless molars, where the folds of enamel extend inwards from the entire length of the sides of the tooth, the characteristic configuration of the grinding surface is maintained without variation, as in the Guinea-pig, the Capybara, and the Patagonian Cavy.

The whole exterior of the molar teeth of the *Rodentia* is covered by cement, and the external interspaces of the enamel-folds are filled with the same substance. In the *Chinchillidæ* and the Capybara, where the folds of enamel extend quite across the body of the tooth, and insulate as many plates of dentine, these detached portions are held together by the cement. Such folds of enamel are usually parallel, as in the large posterior lower molar of the Capybara, which, in shape and structure, offers a very close and interesting resemblance to the molars of the Asiatic Elephant.

The modification observed in the Voles (*Arvicola*) calls to mind the molars of the African Elephant and some mastodons. The partial folds and islands of enamel in the molars of the Porcupine and Agouti typify the structure of the teeth of the Rhinoceros. The

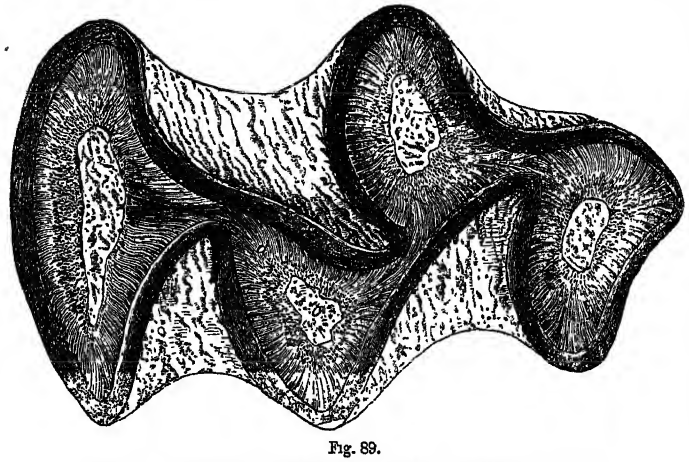

Fig. 89.

Structure of the Molar of the Water-Vole (*Arvicola amphibia*), magnified.

opposite lateral inflections of enamel in the molars of the Gerbille and Cape Mole-rat, represent the structure of the molars of the Hippopotamus. The double crescentic folds in the Jerboa sketch out, as it were, the characteristic structure of the molars of the Anoplothere and Ruminants, &c.

The transverse section of the molar of the Water-vole (fig. 89) shows that modification of the grinding surface in which the folds of enamel (*e*) extend like promontories, some outwards, the others inwards, into the substance of the crown; a like section of the Beaver's molar exhibits islands with a promontory of enamel. The transverse section of the crown of the molar of *Lagostomus* displays not fewer than five islands of enamel, which hard substance is so thick that it enters more abundantly into the composition of the tooth than the dentine itself.

The pulp, after the formation of a certain thickness of tubular dentine, becomes converted into osteo-dentine in both the rooted and rootless molars of the Rodents. This fourth substance is exhibited at *o* in the magnified transverse section of the Water-vole's molar (fig. 89), which shows the four different dental tissues, viz. cement (*c*), enamel (*e*), dentine (*d*), and osteo-dentine (*o*), entering in more equal proportions into the formation of the crown than has hitherto been demonstrated in any other mammalian tooth. When the crown is worn by mastication down to the place of the section figured, the four substances appear in the same proportions on the grinding surface, contributing to its efficiency as a triturating organ by the inequalities consequent on their various degrees of density and resistance to the abrading forces.

The molars are not numerous in any Rodent; the Hare and Rabbit (*Lepus*), have $\frac{6}{5}:\frac{6}{5}$, *i. e.*, six molars on each side of the upper jaw (fig. 90), and five on each side of the lower jaw (fig. 91). The Pika (*Lagomys*), has $\frac{6}{5}:\frac{6}{5}$. The Squirrels have $\frac{5}{4}:\frac{5}{4}$. The families of the Dormice, the Porcupines, the Spring-rats (*Echimyidæ*), the Octodonts, the Chinchillas, and the Cavies (fig. 88), have $\frac{4}{4}:\frac{4}{4}$ molars. In the great family of Rats (*Muridæ*), the normal number of molars is $\frac{3}{3}:\frac{3}{3}$; but the Australian Water-rat (*Hydromys*), has but $\frac{2}{2}:\frac{2}{2}$ molars, making, with the incisors, twelve teeth, which is the smallest number in the Rodent order. The greatest number of teeth in the present order is twenty-eight, which is exemplified in the Hare and Rabbit; but forty teeth are developed in these species, ten molars and two incisors being deciduous.

In all the Rodents in which the number of molars exceeds three in a series, the additional ones are anterior to them, and are premolars, *i. e.*, they have each displaced a deciduous predecessor in the vertical direction. This it is which constitutes the essential distinction between the dentition of the marsupial and the placental Rodent; the latter, like the placental *Carnivora*, *Quadrumana*, and *Ungulata*, having never more than three true molars. Thus the Rodents which have the molar formula of $\frac{4}{4}:\frac{4}{4}$, shed the first tooth in each series, and this is succeeded by a permanent premolar which comes into place later than the true molars—later at least than the first and second, even when the deciduous molar is shed before birth, as was observed by Cuvier in the Guinea Pig. In the Hare and Rabbit, three anterior teeth in the upper jaw (fig. 90 *p*) succeed and displace three deciduous predecessors (fig. 90, *d*), coming into place after the first and second true molars (fig. 90, *m*) are in use, and contemporaneously with the last molar. It does not appear that the scalpriform incisors (fig. 90, *i*) are preceded by milk teeth, or, like the premolars of the Guinea Pig, by uterine teeth; but the second incisor (fig. 90, *i* 2) is so preceded—*e. g.*, by the tooth marked *d*, *i*, 2, at which period of dentition six incisors are present in the upper jaw.[2] This condition is interesting both as a transitory manifestation of the normal number of incisive teeth in the mammalian series, and it elucidates the disputed nature of the great anterior scalpriform teeth of the Rodentia.

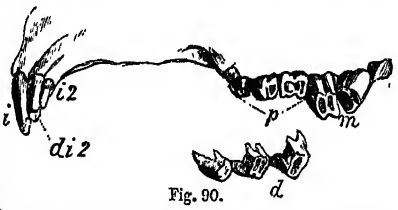

Fig. 90.

Upper Deciduous and Permanent Teeth of the Hare.

Geoffroy St Hilaire contended[3] that the scalpriform teeth of the Rodents were canines, because those of the upper jaw extended their fang backwards into the maxillary bone, which lodged part of

[1] See *Natural History of the Mammalia*, by G. R. Waterhouse; order Rodentia. 8vo, 1849. *Ossemens Fossiles*, G. Cuvier. *Les Dents de Mammifères*, F. Cuvier.

[2] Pl. 104, fig. 5.

[2] Geoffroy St Hilaire, in his *Systeme Dentaire d'Oiseaux*, 8vo, 1824, Appendix, p. 73, claims the discovery for himself by prevision, and for his assistant Delalande by demonstration, of this interesting fact. "Je vis là un mode d'arrangement, comme on l'avait observé chez les Kangurcos; *et dans la chaleur d'improvisation*, je m'avisai d ajouter que peut-être un cas d'atrophie avait causé l'absence de les trèisieme paire de dents, laquelle, ne manquant chez les lapins que pour ce motif, n'emêpcherait pas qu'ils ne fussent, tout aussi bien à l'égard des incisives que sous d'autres rapports, comparables aux Kanguroos. J'etais comme de cotume accompagné de M. Delalande, qui préparait mes leçons; il prit confiance dans mon apperçu; il fit, dans un intervalle de deux jours, et sans m'en parler, des recherches a cet égard; et, à la leçon suivant, il me surprit en me présentant devant les élèves plusieurs pièces fraîches: 'Voici me dit il, en existence positive, voici en fait, ce que vous avez presenti pouvoir être: voici les têtes des lapins avec six dents incisives.' M. Lemaire de Lisancourt, aujourdhui membre de l'Acad. R. de Médecine, l'un de mes auditeurs à cette epoque, peut se rappeler la vive sensation que cela fit sur les élèves," p. 72.

[3] Isidore Geoffroy St Hilaire cites the opinion in Art. Rongeurs, Dict. Classique d'Histoire Naturelle

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their hollow base and matrix. But the scalpriform teeth are confined exclusively to the premaxillary bones at the beginning of their formation, and the smaller incisors which are developed behind them, in our anomalous native Rodents, the Hare and Rabbit, retain their usual relations with the premaxillaries, thus proving, *a fortiori*, that the tooth which projects anterior to them must also be an incisor.

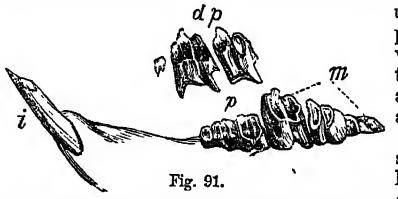

Fig. 91.

Lower Deciduous and Permanent Teeth of the Hare.

Fig. 91 shows the single incisor (*i*) of the lower jaw, the two deciduous molars (*d p*), the two premolars (*p*), and the three molars (*m*), of the young Hare (*Lepus timidus*).

The law of the unlimited growth of the scalpriform incisors is unconditional; and constant exercise and abrasion are required to maintain the normal and serviceable form and proportions of these teeth. When, by accident, an opposing incisor is lost, or when, by the distorted union of a broken jaw, the lower incisors no longer meet the upper ones, as sometimes happens to a wounded hare,[1] the incisors continue to grow until they project like the tusks of the Elephant, and their extremities in the poor animal's painful attempts to acquire food, also become pointed like tusks. Following the curve prescribed to their growth by the form of their socket, their points often return against some part of the head, are pressed through the skin, then cause absorption of the jaw-bone, and again enter the mouth, rendering mastication impracticable, and causing death by starvation.

In the Museum of the College of Surgeons, No. 2203, Osteological Series, there is a lower jaw of a Beaver, in which the scalpriform incisor has, by unchecked growth, described a complete circle. The point has pierced the masseter muscle, and entered the back of the mouth, passing between the condyloid and coronoid processes of the lower jaw, descending to the back part of the molar teeth, in the advance of the part of its own alveolus, which contains its hollow root.

Fig. 92.

Forepart of Upper Jaw of a Rabbit, with Incisors of Abnormal Growth.

The upper jaw of a Rabbit, with an analogous abnormal growth of the scalpriform and accessory incisors, is figured in cut 92.[2]

Order Quadrumana Cheiromys.

Cheiromys.—In this genus of the Lemurine animals, represented by the Aye-aye (fig. 93), as in *Phascolomys* amongst the Marsupials, *Desmodus* amongst the Bats, and *Sorex* amongst the Insectivores, the dentition is modified in analogical conformity with the Rodent type, to which, in the present instant, it makes a very close approximation, the canines being absent, and a wide vacancy separating the single pair of large-curved scalpriform incisors in each jaw from the short series of molars.

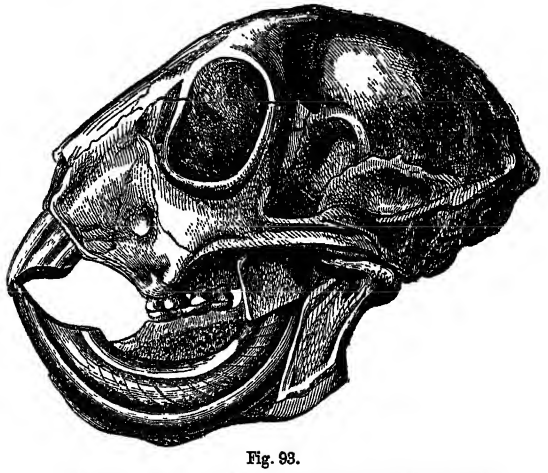

Fig. 93.

Skull and Dentition of the Aye-aye (*Cheiromys Madagascariensis*).

The upper incisors are compressed, presenting a narrow oval transverse section, with the long diameter from before backwards. They are curved in the segment of a circle, and deeply implanted. The short exserted crowns touch one another; their simple widely excavated fangs diverging as they penetrate the substance of the jaw. These crowns also project obliquely forwards, and do not extend vertically downwards, as in the true *Rodentia*.

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The lower incisors are more depressed, and of greater breadth from before backwards, than the upper ones. They are more curved than in the *Rodentia*, describing a semicircle, three-fourths of which are lodged in the socket, which extends backwards beyond the last molar tooth to the base of the coronoid process. The most important character by which the incisors of this anomalous Lemur differ from those of the *Rodentia* is the entire investment of enamel, which is, however, thicker upon the front than upon the back part of the tooth. The molar teeth are four on each side of the upper jaw, and three on each side of the lower jaw; implanted vertically and in parallel lines. The molars are of simple structure, with a continuous outer coat of enamel, and a flat subelliptic grinding surface. The upper ones are of unequal size, the first being the smallest and the second the largest. In the lower jaw the inequality is less, and the last molar is the least. The first and last molars above have but one root; the second and third have each three roots. The first lower molar has two roots; the second and third have each a single root. The dental formula, in the Slow Lemurs (*Stenops*), is—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3} = 36.$$

In the *Stenops Tardigradus*, the first upper incisor is larger than the second, as in the genus *Tarsius*.

Lemur.

The true Lemurs or Makis (*Lemur*, *Geoff*) have the same number and kind of teeth as the Slow Lemurs. The inferior canines are compressed and procumbent like the incisors, but are a little larger. In the upper jaw the incisors are small and vertical, with short expanded crowns; the two on the right side are separated by a wide space from the two on the left. The canine (*c*) is long, curved, compressed, sharp-edged, and pointed. The three premolars have the outer part of the crown prolonged into a compressed pointed lobe, whilst the inner part forms a tubercle, which is largest in the second and third. In the true molars the inner division of the crown is so increased as to give it a quadrate form, the outer division being divided into two pointed lobes. The first of the true molars is the largest in both jaws.

Platyrhynæ.

All the Quadrumana of America are distinguished from the Apes and Monkeys of the Old World by certain well-marked characters; of these, the position of the nostrils at the sides of the broad nose, whence their collective name, is the most conspicuous; but they have a more important dental distinction in the superior number of the premolars, which are $\frac{2}{2}\cdot\frac{3}{3}$ instead of $\frac{2}{2}\cdot\frac{2}{2}$, whereby the American Monkeys manifest their closer affinity to the Lemurs, and their inferior position in the zoological scale. The small "Marmosets," however, forming the genera *Hapale* and *Midas*, have but two true molar teeth on each side of both jaws—their dental formula being—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{2.2}{2.2} = 32.$$

The lemurine character of the long, narrow, inferior incisors continues to be manifested by the Sakis (*Pithecia Ill.*), which, like the larger species of Platyrhines called Howlers, Capuchins, and Spider-Monkeys, have the normal number of true molar teeth in the Quadrumanous order—their dental formula being—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3} = 36.$$

The Capuchin Monkeys (*Cebus*) (fig. 94) have the four lower incisors (*i*) with broad, thick wedge-shaped trenchant crowns; a form

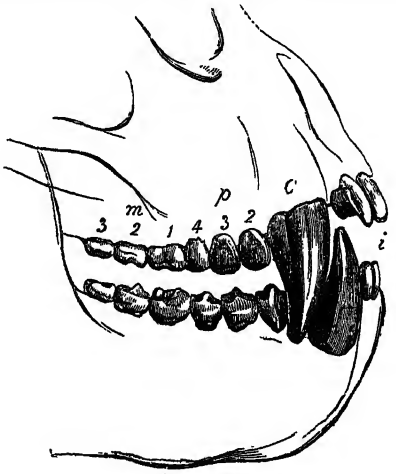

Fig. 94.

Dentition of a Capuchin Monkey (*Cebus secniulus*).

[1] Professor Budge has described and figured the upper and lower jaws of a hare with preternaturally directed and elongated tusks, in the *Verhandlingen des Naturhistor, Vereines der Treuss.* Rheinlande, 6tes Jahrgang. 8vo, 1849, p. 506.

[2] See the specimens, Nos. 1966-1971, *Mus. Coll. Chir.* Lond.

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which these teeth retain, with slight modifications, throughout the rest of the Quadrumanous order. The canines (*c*) are sufficiently developed to inflict severe wounds. The first three of the molar series (*p*, 2. 3, 4) are bicuspid premolars; the rest (*m*, 1, 2, 3) are quadricuspid true molars.

All the Platyrhine Monkeys have four more teeth in their first dentition than the Catarhine or Old World Quadrumanes possess—the deciduous formula being—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ m\,\frac{3.3}{3.3} = 24.$$

Fig. 95 shows the deciduous series in place, together with the first of the permanent true molars (*m*, 1); the germs of the rest of the permanent teeth are exposed in the upper jaw.

Catarhina.

In the Catarhine division of the order, the first or deciduous dentition consists, as in man, of—

$$i\,\frac{2.2}{2.2};\ p\,\frac{1.1}{1.1};\ m\,\frac{2.2}{2.2} = 20.$$

The two milk molars are displaced and succeeded vertically by the two bicuspid premolars, and are followed horizontally by three true molars on each side of both upper and lower jaws. The permanent formula in all the Old World *Quadrumana* is—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{2.2};\ m\,\frac{3.3}{3.3} = 32.$$

The incisors have always a shape conformable to their name, but are very thick and strong; in the upper jaw the middle are larger than the lateral ones, and both are larger than those below. The canines are conical, pointed, with trenchant posterior margins, always longer than the adjoining teeth, and acquiring, in the males of the great Baboons and Orangs, the proportions of those teeth in the true *Carnivora*. The Mandrills (*Cynocephalus maimon*) have these dental weapons most formidable for their size and shape; especially the upper pair, which descend behind the crowns of the lower incisors, and along the outside of the first lower premolars, the crowns of which seem as if bent back by the action of the upper canines; the anterior longitudinal groove of these canines is very deep, their posterior margin very sharp. A long diastema divides the upper canine from the incisors, a short one separates it from the premolars; these and the three true molars, are arranged in a straight line.

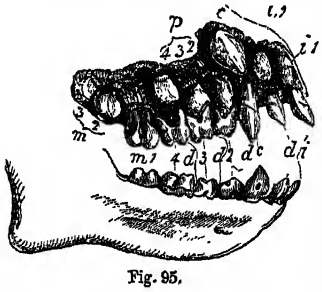

Fig. 95.

Deciduous and Permanent Teeth of a Young *Cebus Apella*.

In the great Orang-utan (*Pithecus Wurmbi*) the median incisors of the upper jaw are of unusual size and strength; the thickness (antero-posterior diameter) of the base of the crown almost equals the breadth of the same; and they are double the size of the lateral incisors. The abraded surface of the front incisors in the old Orang forms a broad tract extending obliquely from the cutting edge to the back part of the base of the crown; the lateral incisors are more pointed, the outer angle being obliquely truncated; a vacant space of their own breadth divides them from the canines. These, in the male of the Great Orang (Wurmb's Pongo), have a long and strong slightly-curved crown, extending below the alveolar border of the under jaw when the mouth is shut, with a moderately sharp posterior margin, but without an anterior groove; the crown is convex externally, with a slight convexity between two longitudinal depressions on the inner surface. In the female Orang the canines are smaller; the crowns extend only a short distance beyond the level of the adjoining molars.[1]

In the upper jaw both premolars and molars are implanted by three diverging roots, two external and one internal; in the lower jaw the corresponding teeth are each implanted by two strong diverging roots; the series of grinders forms a straight line on each side of both jaws.

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As the precise characteristics of the human dentition are best demonstrated by comparison with that brute species which is most nearly allied to man, and makes the first step in the descending scale, the details of such a comparison may perhaps be not unacceptable, as one of its subjects is a species of Chimpanzee (*Troglodytes Gorilla*), unknown to science when the writer's "Odontography" was published, and which, so far as its organization is known, is more anthropoid than even the docile and smaller species of Chimpanzee (*Troglodytes niger*). A side view of the teeth of a male full-grown, but not aged, specimen of the great Chimpanzee is given of the natural size in (fig. 96). This dentition, though in all its principal characters strictly quadrumanous, yet, in the minor particulars in which it differs from the dentition of the Orang, approaches nearer the human type. In the upper jaw the middle incisors (*i*) are smaller, the lateral ones (fig. 96, *i*, 2) larger than those of the Orang; they are thus more nearly equal to each other; nevertheless the proportional superiority of the middle pair is much greater than in Man, and the proportional size of the four incisors both to the entire skull and to the other teeth is greater. Each incisor has a prominent posterior basal ridge, and the outer angle of the lateral incisors (*i*, 2) is rounded off as in the Orang. The incisors incline forwards from the vertical line as much as in the great Orang. Thus the characteristics of the human incisors are, in addition to their true incisive wedge-like form, their near equality of size, their vertical or nearly vertical position, and small relative size to the other teeth and to the entire skull. The diastema between the incisors and the canine on each side is as well marked in the male Gorilla as in the male Orang. The crown of the canine (fig. 96, *c*), passing outside the interspace between the lower canine and premolar, extends in the male *Troglodytes Gorilla* a little below the alveolar border of the under jaw when the mouth is shut; the upper canine of the male *Troglodytes niger* likewise projects a little below that border. In the male of the smaller Chimpanzee (*Troglodytes niger*), the upper canine is conical, pointed, but more compressed than in the Orang, and with a sharper posterior edge; convex anteriorly, becoming flatter at the posterior half of the outer surface, and concave on the corresponding part of the inner surface, which is traversed by a shallow longitudinal impression; a feeble longitudinal rising, and a second linear impression divide this from the convex anterior surface, which also bears a longitudinal groove at the base of the crown. The canine is rather more than twice the size of that in the female. In the male *Gorilla* (fig. 96, *c*), the crown of the canine is more inclined outwards; the anterior groove on the inner surface of the crown is deeper; the posterior groove is continued lower down upon the fang, and the ridge between the two grooves is more prominent than in the *Troglodytes niger*. Both premolars (fig. 96, *p* 3 and *p* 4) are bicuspid; the outer cusp of the first, and the inner cusp of the second being the largest, and the first premolar (*p* 3) consequently appearing the largest on an external view. The difference is well marked in the

Chimpanzee Troglodytes.

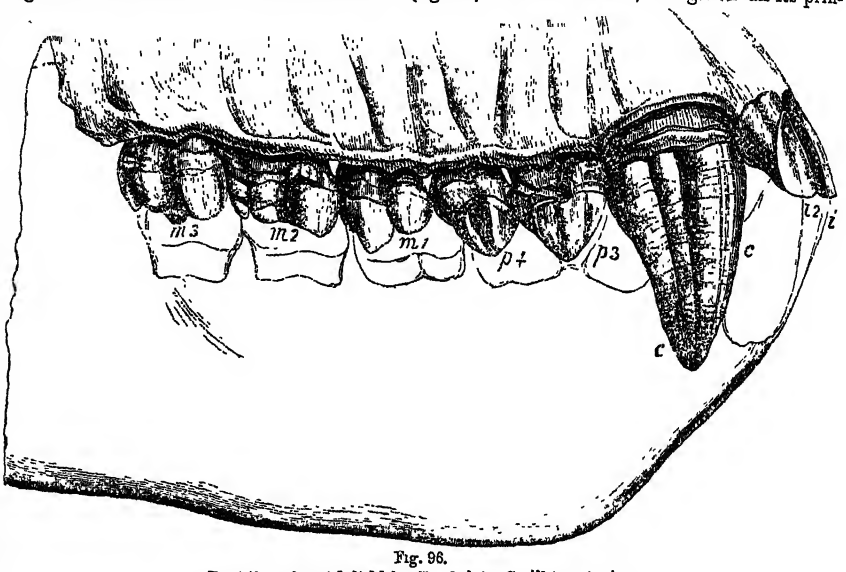

Fig. 96.

Dentition of an Adult Male (*Troglodytes Gorilla*), nat. size.

[1] In the writer's *Odontography* (1842, p. 442) is recorded a variety which he observed in the dentition of a full-grown Orang-utan, in the collection of the Baron Van der Capella at Utrecht, viz., a supernumerary molar on each side of both jaws, making six molars, of which two only had the form of premolars.

In the Calcutta museum Mr Blyth has noticed in an adult female Bornean Orang, a fourth true molar on the left side of both upper and lower jaw, the supernumerary tooth above being of a round shape, and very small.

In a collection of skulls of the smaller species of Orang recently sent from Borneo (*Pithecus Morio*), the writer observed the skull of an adult male with the same supernumerary molar on each side of the upper jaw, but not in the lower jaw.—*Trans. Zool. Soc.*

These instances illustrate the tendency to variety in the remarkable Anthropoid Apes of Borneo, a tendency which seems to be also manifested in an occasional arrest of development of the characteristic long upper extremities.

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female (fig. 97). The anterior external angle of the first premolar is not produced as in the Orang, which in this respect makes a marked approach to the lower *Quadrumana*. In Man, where the outer curve

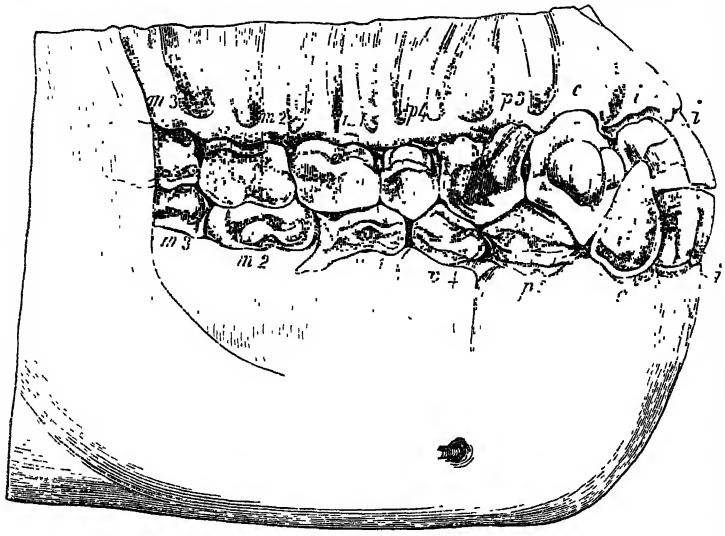

Fig. 97.

Dentition of an Adult Female Gorilla.

of the premolar part of the dental series is greater than the inner one, the outer cusps of both premolars are the largest; the alternating superiority of size in the Chimpanzee accords with the straight line which the canine and premolars form with the true molars.

The true molars (fig. 96, *m* 1, *m* 2, *m* 3) are quadricuspid, relatively larger in comparison with the bicuspids than in the Orang. In the first and second molars of both species of Chimpanzee, a low ridge connects the antero-internal with the postero-external cusp, crossing the crown obliquely, as in Man. There is a feeble indication of the same ridge in the unworn molars of the Orang; but the four principal cusps are much less distinct, and the whole grinding surface is flatter and more wrinkled than in the Chimpanzee. In the *Troglodytes niger* the last molar is the smallest, owing to the inferior development of the two hinder cusps, and the oblique connecting ridge is feebly marked. In the *Troglodytes Gorilla* this ridge is as well developed as in the other molars, but is more transverse in position; and the crown of *m* 3 is equal in size to that of *m* 1 or *m* 2, having the posterior outer cusp, and particularly the posterior inner cusp, more distinctly developed than in the *Troglodytes niger*. The repetition of the strong sigmoid curves which the unworn prominences of the first and second true molars present in Man, is a very significant indication of the near affinity of the Chimpanzee as compared with the approach made by the Orangs or any of the inferior *Quadrumana*, in which the four cusps of the true molars rise distinct and independently of each other. A low ridge girts the base of the antero-internal cusp of each of the upper true molars in the male Chimpanzee; it is less marked in the female. The premolars as well as molars are severally implanted by one internal and two external fangs, diverging but curving towards each other at their ends, as if grasping the substance of the jaw. I have found the two outer fangs of the second premolar connate in one female specimen of the *Troglodytes niger*. In no variety of the human species are the premolars normally implanted by three fangs; at most the root is bifid, and the outer and inner divisions of the root are commonly connate. It is only in the black varieties, and more particularly that race inhabiting Australia, that I have found the wisdom tooth (*m* 3) with three fangs as a general rule; and the two outer ones are more or less confluent.

In the lower jaw of the Gorilla the lateral incisors are broader than the middle ones, although they are smaller relatively than in the *Troglodytes niger;* they are larger and less vertically implanted than in Man. The lower canines are two inches and a half in length, including the root; the enamelled crown is an inch and a quarter in length, and nearly an inch across the base; it is conical and trihedral; the outer and anterior surface is convex, the other two surfaces are flattened or subconcave, and converging to an almost trenchant edge directed inwards and backwards; a ridge separates the convex from the antero-internal flat surface; both this and the posterior surface show slight traces of a longitudinal rising at their middle part. The lower canine of the male shows the same relative superiority of size as the upper one compared with that in the female in both species of Chimpanzee. The canine almost touches the incisor, but is separated by a diastema one line and a half broad from the first premolar. This tooth (*p* 3) is larger externally than the second premolar, and is three times the size of the human first premolar (*p* 3); it has a subtrihedral crown, with the anterior and outer angle produced forwards, slightly indicating the peculiar feature of the same tooth in the Baboons, but in a less degree than in the Orang. The summit of the crown of *p* 3 terminates in two sharp trihedral cusps—the outer one rising highest, and the second cusp being feebly indicated on the ridge extending from the inner side of the first; the crown has also a thick ridge at the inner and posterior part of its base. The second premolar (*p* 4) has a subquadrate crown, with the two cusps developed from its anterior half, and a third smaller one from the inner angle of the posterior ridge. Each lower premolar is implanted by two antero-posteriorly compressed divergent fangs, one in front of the other, the anterior fang being the largest.

Teeth of Mammals.

The three true molars are equal in size in the *Troglodytes Gorilla;* in the *Troglodytes niger* (fig. 98), the first (*m* 1) is a little larger than the last (*m* 3), which is the only molar in the smaller Chimpanzee as large as the corresponding tooth in the black varieties of the human subject, in most of which, especially the Australians (fig. 99), the true molars attain larger dimensions than in the yellow or white races. The four principal cusps, especially the two inner ones of the first molar of both species of Chimpanzee, are more pointed and prolonged than in Man; a fifth small cusp is developed behind the outer pair, as in the Orangs and the Gibbons, but is less than that in Man. The same additional cusp is present in the second molar, which is seldom seen in Man. The crucial groove on the grinding surface is much less distinct than in Man, not being continued across the ridge connecting the anterior pair of cusps in the Chimpanzee. The crown of the third molar is longer antero-posteriorly from the greater development of the fifth posterior cusp, which, however, is rudimental in comparison with that in the Semnopitheques and Macaques. All the three true molars are supported by two distinct and well-developed antero-posteriorly compressed divergent fangs, longitudinally excavated on the sides turned towards each other; in the white and yellow races of the human subject these fangs are usually connate in *m* 3, and sometimes also in *m* 2. The molar series in both species of Chimpanzee forms a straight line, with a slight tendency, in the upper jaw, to bend in the opposite direction to the well-marked curve which the same series describes in the human subject.

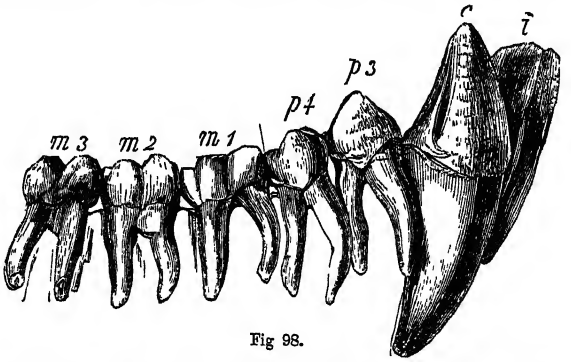

Fig 98.

Teeth of Right Side, Lower Jaw, of adult male Chimpanzee, (*Troglodytes niger*). Nat. size.

This difference of arrangement, with the more complex implantation of the premolars, the proportionally larger size of the incisors as compared with the molars; the still greater relative magnitude of the canines; and, above all, the sexual distinction in that respect illustrated by figs. 96 and 97, stamp the Gorillas and Chimpanzees most decisively with not merely specific but generic distinctive characters as compared with Man. For the teeth are fashioned in their shape and proportions in the dark recesses of their closed formative alveoli, and do not come into the sphere of operation of external modifying causes until the full size of the crowns has been acquired. The formidable natural weapons with which the Creator has armed the powerful males of both species of Chimpanzee, form the compensation for the want of that psychical capacity to forge destructive instruments which has been reserved, as his exclusive prerogative, for Man. Both Chimpanzees and Orangs differ from the human subject in the order of the development of the permanent series of teeth; the second molar (*m* 2) comes into place before either of the premolars has cut the gum, and the last molar (*m* 3) is acquired before the canine. We may well suppose that the larger grinders are earlier required by the frugivorous Chimpanzees and Orangs than by the higher organized omnivorous species with more numerous and

Teeth of Mammals.

varied resources, and probably one main condition of the earlier development of the canines and premolars in Man may be their smaller relative size.

Homo.

Having reached, in the Gorilla, the highest step in the series of the brute creation, our succeeding survey of the human dental system, cleared and expanded by retrospective comparison, becomes fraught with peculiar interest, since every difference so detected establishes the true and essential characteristics of that part of man's frame.

The human teeth are the same in number and in kind as those of the Chimpanzee and Orang-utan, nor does man differ in this respect from any of the inferior catarhine Quadrumanes. The human dental formula is therefore—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{2.2};\ m\,\frac{3.3}{3.3} = 32;$$

that is to say, there are on each side of the jaw, both above and below, two incisors, one canine, two premolars, and three true molars.

They are more equal in size than in the *Quadrumana*. No tooth surpasses another in the depth of its crown; and the entire series, which describes in both jaws a regular parabolic curve, is uninterrupted by any vacant space (fig. 99). The most marked distinction

Fig. 99.

Teeth of Left Side, Lower Jaw, of Adult Male Australian. Nat. size.

between the dentition of Man and that of the highest Quadrumanes, is the absence of the interval between the upper lateral incisor and the canine, and the comparatively small size of the latter tooth (fig. 100, *c*); but its true character is indicated by the conical form of the crown, which terminates in an obtuse point, is convex outwards, and flat or sub-concave within, at the base of which surface there is a feeble prominence. The conical form is best expressed in the Melanian races, especially the Australian (fig. 99, *c*). The canine is more deeply implanted, and by a stronger fang than the incisors; but the contrast with the Chimpanzee is sufficiently manifest, as is shown in fig. 98. There is no sexual superiority of size either of the canine or any other single tooth in the human subject.

Both upper and lower premolars (fig. 99, *p* 3 and 4) are bicuspid; they are smaller in proportion to the true molars than in the Chimpanzee and Orang. In the upper premolars a deep straight fissure at the middle of the crown divides the outer and larger from the inner and smaller cusp; in the lower premolars the boundary groove describes a curve concave towards the outer cusp, and is sometimes obliterated in the middle by the extension of a ridge from the outer to the inner cusp, which cusp is smaller in proportion than in the upper premolars. These teeth in both jaws are apparently implanted each by a single, long, subcompressed, conical fang; but that of the upper premolars is shown by the bifurcated pulp-cavity to be essentially two fangs, connate, and which, in some instances, are separated at their extremities.

The crowns of the true molars fig. 99, *m* 1, 2, 3) are larger in proportion to the jaws, are a little larger in proportion to the bicuspids, and still more so in proportion to the canine and incisor teeth, than in the Chimpanzees and Orangs. The contour of the grinding surface is more rounded, and we have seen that the higher *Quadrumana* already approximate to this character by the angles of the crown being less marked than in the lower *Quadrumana*. The first and second true molars of the upper jaw support four trihedral cusps; the internal and anterior one is the largest, and is connected with the external and posterior cusp by a low ridge extending obliquely across the grinding surface, with a deep depression on each side of it; the anterior groove extending to the middle of the outer surface, the posterior one to the inner surface. The enamel is first worn away by mastication from the anterior and internal or largest tubercle, a line of enamel extending from the outside to the middle of the crown is the last to be removed before the grinding surface is reduced to a field of dentine with a simple ring of enamel. It is worthy of remark, that by the time when the permanent teeth have come into place the first true molar in both jaws is much more worn, as compared with the second and third molars, than it is in the Chimpanzee or Orang, owing to the slow attainment of maturity characteristic of the human species, and the longer interval which elapses between the acquisition of the first and the last true molars, than in the highest *Quadrumana*. In the last true molar, called from its late appearance the "dens sapientiæ," or wisdom-tooth, the two inner tubercles are blended together, and a fissure extends in many instances, especially in the Melanian varieties, from the middle of the grinding surface, at right angles to that dividing the two outer cusps, to the posterior border of the tooth.

Teeth of Mammals.

The first upper molar is always implanted by three diverging fangs, two external and one internal. The second molar is usually similarly implanted, but the two outer fangs are less divergent, are sometimes parallel, and occasionally connate; this variety appears to be more common in the Caucasian than in the Melanian races; and in the Australian skulls examined by the writer, the wisdom-tooth has always presented the same three-fanged implantation as in the Chimpanzee and Orang.

The crowns of the inferior true molars are quinque-cuspid, the fifth cusp being posterior and connected with the second outer cusp; it is occasionally obsolete in the second molar. The four normal cusps are defined by a crucial impression, the posterior branch of which bifurcates to include the fifth cusp; this bifurcation being most marked in the last molar where the fifth cusp is most developed. In the first molar a fold of enamel, extending from the inner surface to the middle of the crown, is the last to disappear from the grinding surface in the course of abrasion. The wisdom-tooth (fig. 99, *m* 3) is the smallest of the three molars in both jaws, but the difference is less in the Melanian than in the Caucasian races. Each of the three lower molars is inserted by two sub-compressed fangs, grooved along the side, turned towards each other. This double implantation appears to be constant in the Melanian, especially the Australian race (fig. 99), in which the true molars are relatively larger than those of the Caucasian race. In Europeans it is not unusual to find the two fangs in both the second and third molars connate along a great part or the whole of their extent.

With respect to the reciprocal apposition of the teeth of the upper and under jaw, it is interesting to observe that the crown of the lower canine is, as usual, in advance of that above, and fits into the shallow notch between that and the lateral incisor. The inferior incisors are so small that their anterior surface rests against the posterior surface of the upper ones when the mouth is closed; the other teeth are opposed crown to crown, the upper teeth extending a little more outwardly than the lower ones.

Hunter remarks that the supernumerary teeth happen oftener in the upper than in the under jaw, and he believed them to be always incisors or canines. In the Osteological series of the Museum of the London College of Surgeons there is a skull of a male Hindoo (No. 5541), in which there were two well-formed canine teeth placed side by side in the left upper jaw, the series being very regular and even. The wisdom-tooth is sometimes not developed.

The deciduous series of teeth in the human subject (fig. 100) consists of—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ m\,\frac{2.2}{2.2} = 20.$$

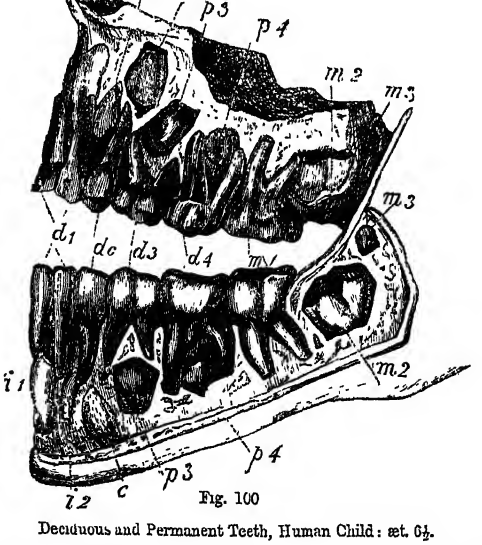

Fig. 100

Deciduous and Permanent Teeth, Human Child: æt. 6½.

Comparison of the deciduous teeth in Man, the Chimpanzee, and Orang.

The upper milk incisors of the Chimpanzee are relatively larger than in Man, especially the middle pair; but the disproportionate size of these is still more manifest and characteristic of the Orang. The crown of the canine is longer and more pointed in the Chimpanzee than in Man; still more so, and further apart from the incisor in the Orang. The first upper milk-molar (fig. 100, *d* 3) is as large in the human subject as in the Chimpanzee, and its crown is divided into two principal cusps, but the outer and larger one has a small subdivision notched off posteriorly, and the inner cusp is relatively larger than in the Chimpanzee. The first upper milk-molar of the Orang is simply bicuspid, but is larger than in the Chimpanzee. The second milk-molar of the human child (fig. 100, *d* 4) could scarcely be distinguished from that of the young Chimpanzee; both are quadricuspid, and the same oblique ridge crosses the grinding surface from the antero-internal to the postero-externa

Teeth of Mammals.

tubercle; but the pointed summits of the two outer cusps are a little more produced in the Chimpanzee. The second molar of the Orang, besides its larger size, has the four tubercles better defined, and the oblique ridge less developed. The lower deciduous incisors of the anthropoid Apes differ from those of the human subject in their superior size, greater relative thickness, and, in the lateral incisor more particularly, by the rounding off of the outer angle. The lower canine of the Chimpanzee has a longer, larger, and more pointed crown, with a sharp posterior edge; it is less marked in the canine of the Orang, which is larger and thicker than in the Chimpanzee. The crowns of the upper and lower canines are more obliquely opposed, the lower one being more advanced in those apes than in the human subject. The first lower deciduous molar of the human subject has four tubercles and a small anterior ridge, and is larger than that of the Chimpanzee, which supports a single large-pointed cusp, and a posterior ridge. The corresponding molar of the Orang has a similar simple crown, but is as large as that of the human child. The second lower milk molar (fig. 100, *d* 4) is of equal or superior size in the human subject to that in the Chimpanzee, but it supports three outer and two inner cusps, while in the Chimpanzee it has but four cusps. In the Orang the fifth external and posterior tubercle is feebly indicated. The deciduous molars of the human subject, as in the Chimpanzee and Orang, have each three fangs in the upper, and two in the lower jaw.

The differences brought out by the foregoing comparisons, though less striking than those exhibited by the permanent teeth, will be appreciated by the philosophical anatomist as yielding more certain evidence of the essential distinction of the Bimanous species. He will perceive that they are not due to mere adaptive developments, but are manifested at a period when the subjects of comparison are far from having attained the pre-ordained term of deviation from the common type; that they are antecedent to those changes in the dental system itself, which more broadly characterize the species, and, in the Orang and Chimpanzee, proceed further to differentiate the male and female sexes.

Homo. Development.

Calcification of the permanent series of teeth commences first in the pulp of the first true molar (fig. 100, *m* 1), and, very soon after, if not simultaneously, in that of the anterior incisor (*i* 1), about five or six months after birth. The first true molar (*m* 1) comes into place and use between the sixth and seventh year; the first permanent incisor (*i* 1) between six years and a half and eight years; the calcification of the pulps of the lateral incisor (*i* 2) and canine (*c*) commences about eight or nine months after birth, and they cut the gum, the canine quickly following the incisor, between the seventh and ninth years. Calcification of the first premolar (*bicuspis*, *p* 3) begins at, or soon after, the second year; that of the second about a year later; and both premolars (*p* 3 and 4) have displaced the deciduous molars (*d* 3 and 4), and come into use between the eighth and tenth years. The pulp of the second molar (*m* 2) begins to be calcified about the fifth or sixth year, and it cuts the gum from about the twelfth year to the fourteenth year, but always later than the permanent canines and premolars. The third molar (*m* 3) begins to be calcified about the twelfth year, and usually comes into place at or after the twentieth year.

Both earlier and later periods of the development of the permanent teeth have been observed and recorded; but such varieties rarely affect the general order of succession. This order is here described as it occurs in the lower jaw, the teeth of which usually appear earlier than the corresponding ones above. It will be seen, therefore, that the human subject differs from the Chimpanzee and Orang in the order of progression of the permanent teeth.

John Hunter, after indicating the first incisor and the first molar as the earliest of the adult teeth that are formed, rightly observes, "The teeth between these two points make a quicker progress than those behind."[1] In the *Quadrumana* the progress is slower, the second molar preceding in the order of development the bicuspid, and the last molar the canines.

Order Carnivora Felis.

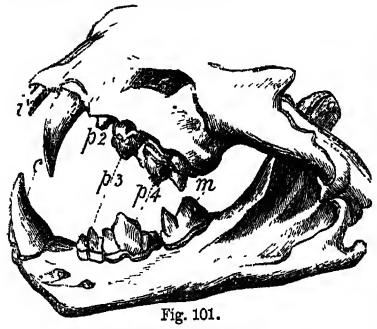

Fig. 101.

Dentition of the Lion.

The Lion (*Felis Leo*) may be taken as the type of the flesh-feeders. The largest and most conspicuous teeth in this and the other feline quadrupeds are the canines (fig. 101, *c*); they are of great strength, deeply implanted in the jaw, with the fangs thicker and longer than the enamelled crown; this part is conical, slightly recurved, sharp-pointed, convex in front, with one or two longitudinal grooves on the outer side, almost flat on the inner side, and with a sharp edge behind. The lower canines pass in front of the upper ones when the mouth is closed.

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The incisors, six in number on both jaws, form a transverse row; the outermost above (fig. 101, *i*) is the longest, resembling a small canine; the intermediate ones have broad and thick crowns indented by a transverse cleft. The first upper premolar (*p* 2) is rudimental; there is no answerable tooth in the lower jaw. The second (*p* 3), in both jaws, has a strong conical crown supported on two fangs. The third upper tooth (*p* 4) has a cutting or trenchant crown divided into three lobes, the last being the largest, and with a flat inner side, against which the cutting tooth (*m*) in the lower jaw works obliquely. Behind, and on the inner side of the upper tooth (*p* 4), there is a small tubercular tooth. The feline dental formula is—

$$i\,\tfrac{3.3}{3.3};\ c\,\tfrac{1.1}{1.1};\ p\,\tfrac{3.3}{2.2};\ m\,\tfrac{1.1}{1.1} = 30.$$

A glance at the long sub-compressed, trenchant, and sharp-pointed canines, suffices to appreciate their peculiar adaptation to seize, to hold, to pierce, and lacerate a struggling prey. The jaws are strong, but shorter than in other carnivora, and with a concomitant reduction in the number of teeth; thus the canines are brought nearer to the insertion of the very powerful biting muscles, called "temporal" and "masseter," which work them with proportionally greater force. The use of the small pincer-shaped incisor teeth is to gnaw the soft, grisly ends of the bones, and to tear and scrape off the tendinous attachments of the muscles and periosteum. The compressed trenchant blades of the sectorial teeth play vertically upon each other's sides like the blades of scissors, serving to cut and coarsely divide the flesh; and the form of the joint of the lower jaw almost restricts its movement to the vertical direction, up and down. The wide and deep zygomatic arches, and the high crests of bone upon the skull concur in completing the carnivorous physiognomy of this most formidable existing species of the feline tribe.

The penultimate tooth in the upper jaw (fig. 101, *p* 4), and the last tooth in the lower jaw (fig. 101, *m*), were denominated by Cuvier "dents carnassières," which has been rendered "dens sectorius," the "sectorial," or scissor-tooth.[2] It is a very characteristic tooth in the carnivorous order, but undergoes many modifications, and preserves its typical form, as represented in figures 102 and 103, only in the most strictly flesh-feeding species. In it may be distinguished the part called the "blade" (fig. 102, *b*, *b*), and the part called the "tubercule" (fig. 102, *t*). The lower sectorial in the genus *Felis* consists exclusively of the blade (fig. 103), which is pretty equally divided into two lobes. The blade of the upper sectorial always plays upon the outside, and a little in advance of the lower sectorial.

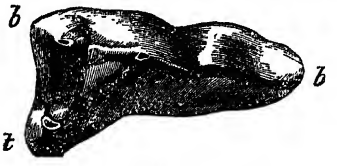

Fig. 102.

Working Surface of the Upper Sectorial Tooth, Hyæna. Nat. size.

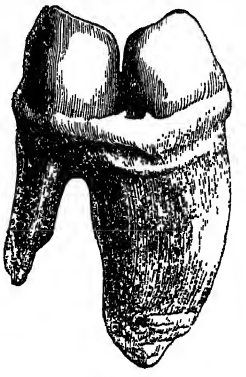

Fig. 103.

Side view of Lower Sectorial Tooth Lion. Nat. size.

Develop-ment.

The upper permanent sectorial (fig. 104, *p* 4) succeeds and displaces a deciduous tubercular molar (fig. 104, *d* 4) in all carnivora, and is, therefore, essentially a premolar tooth; the lower sectorial (fig. 104, *m* 1) comes up behind the deciduous series (*d* 3, *d* 4) and has no immediate predecessor; it is, therefore, a true molar, and the first of that class. By these criteria the sectorial teeth may always be distinguished under every transitional variety of form which they present in the carnivorous series, from *Machairodus* (fig. 145, VI.), in which the crown consists exclusively of the "blade" in both jaws, to *Ursus* (fig. 109), in which it is totally tubercular; the development of the tubercle bearing an inverse relation to the carnivorous propensities of the species.

Hyæna.

The dentition of this genus presents a nearer approach to the strictly carnivorous type, than in other *Carnivora*, by the reduction of the tubercular molars to a single minute tooth on each side of the upper jaw, the inferior molars being all conical or sectorial teeth; the molar teeth in both jaws are larger and stronger, and the canines smaller in proportion than in the Feline species, from the formula of which the dentition of the hyæna differs numerically only in the retention of an additional premolar tooth, *p* 1 above and *p* 2 below, on each side of both jaws. The dental formula of the genus *Hyæna* is:—

$$i\,\tfrac{3.3}{3.3};\ c\,\tfrac{1\,1}{1.1};\ p\,\tfrac{4.4}{3.3};\ m\,\tfrac{1\,1}{1.1} = 34.$$

[1] *Natural History of the Human Teeth*, 4°, p. 82.

[2] *Odontography*, p. 475.

Teeth of Mammals

The crowns of the incisors form almost a straight transverse line in both jaws, the exterior ones, above, being much larger than the four middle ones, and extending their long and thick inserted base further back; the crown of the upper and outer incisor is strong, conical, recurved, like that of a small canine. The four intermediate small incisors have their crown divided by a transverse cleft into a strong anterior, conical lobe, and a posterior ridge, which is notched vertically; giving the crown the figure of a trefoil. The lower incisors gradually increase in size from the first to the third; this and the second have the crown indented externally; but they have not the posterior notched ridge like the small upper incisors; the apex of their conical crown fits into the interspace of the three lobes of the incisor above. The canines have a smooth convex exterior surface, divided by an anterior and posterior edge from a less convex inner side; this surface is almost flat and of less relative extent in the inferior canines. The first premolar above (*p* 1) is very small, with a low, thick, conical crown; the second presents a sudden increase of size, and an addition of a posterior and internal basal ridge to the strong cone. The third premolar exhibits the same form on a still larger scale, and is remarkable for its great strength. The posterior part of the cone of each of these premolars is traversed by a longitudinal ridge. The fourth premolar above is the carnassial tooth (fig. 102), and has its long blade (*b*, *b*) divided by two notches into three lobes, the first a small thick cone, the second a long and compressed cone, the third a horizontal sinuous trenchant plate; a strong triedral tubercle (*t*) is developed from the inner side of the base of the anterior part of the crown. The single true molar of the upper jaw is a tubercular tooth of small size. The first premolar of the lower jaw, (fig. 105, *p* 2) fits into the interspace between the first and second premolars above, and answers, therefore, to the second lower premolar in the *Viverridæ*; it is accordingly much larger than the first (*p* 1) above; it has a ridge in the forepart of its cone, and a broad basal talon behind. The second (fig. 105, *p* 3) is the largest of the lower premolars, has an anterior and a posterior basal ridge, with a vertical ridge ascending upon the fore as well as the back part of the strong rounded cone; the third premolar (*p* 4) is portionably less in the *Hyæna crocuta* than in the *H. vulgaris;* its posterior ridge is developed into a small cone; the last tooth (*m* 1) is the sectorial, and consists almost entirely of a blade divided by a vertical fissure into two sub-equal compressed pointed lobes; the points are less produced than in the Felines, but the lower sectorial of the hyæna is better distinguished by the small posterior basal talon, from which a ridge is continued along the inner side of the base, and is slightly thickened at the forepart of the crown.

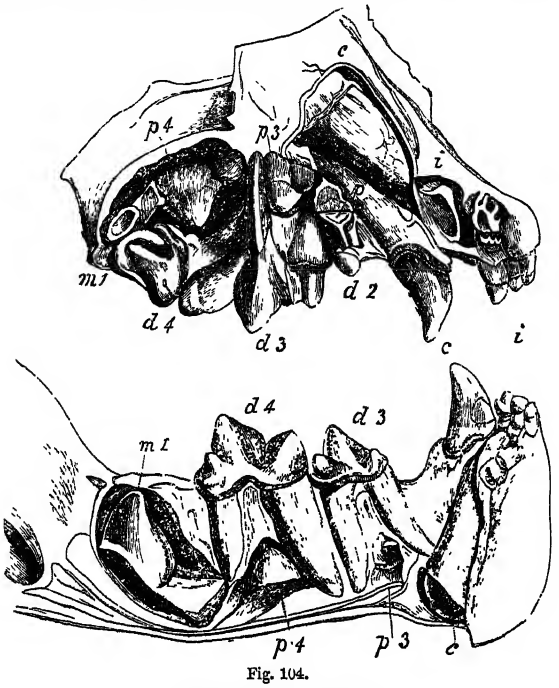

Fig. 104.

Deciduous Teeth; young Lion.

Fig. 105.

Dentition, Lower Jaw, of the Hyæna.

Teeth of Mammals.

The deciduous teeth consist of—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ m\,\frac{3.3}{3.3} = 22.$$

The first normal deciduous molar is two-fanged, and has a more compressed and consequently more carnassial crown than that of the second permanent premolar, by which it is succeeded. The second deciduous molar is the sectorial tooth; the inner tubercle is continued from the base of the middle lobe, and thus resembles the permanent sectorial of the Glutton (*Gulo*) and many other *Mustelidæ;* the deciduous tubercular molar is relatively larger than in the adult *Hyæna*, and offers another feature of resemblance to the permanent dentition of the Glutton. It is also worthy of remark that the exterior incisor of the upper jaw is not only absolutely, but relatively smaller in the immature than in the adult dentition of the hyæna, and again illustrates the resemblance to the more common type of dentition in the Carnivora.

The permanent dentition of the *Hyæna*, as of other genera or families of the Carnivora, assumes those characteristics which adapt it for the peculiar food and habits of the adult, and mark the deviation from the common type, which always accompanies the progress to maturity. The most characteristic modification of this dentition is the great size and strength of the molars as compared with the canines, and more especially the thick and strong conical crowns of the second and third premolars in both jaws, the base of the cone being belted by a strong ridge which defends the subjacent gum.[1] This form of tooth is especially adapted for gnawing and breaking bones, and the whole cranium has its shape modified by the enormous development of the muscles which work the jaws and teeth in this operation.[2] Adapted to obtain its food from the coarser parts of animals which are left by the nobler beasts of prey, the hyæna chiefly seeks the dead carcass, and bears the same relation to the lion which the vulture does to the eagle. In consequence of the quantity of bones which enter into its food, the excrements consist of solid balls of a yellowish white colour, and of a compact earthy fracture. Such specimens of the substance, known in the old *Materia Medica* by the name of "album græcum," were discovered by Dr Buckland in the celebrated ossiferous cavern at Kirkdale. They were recognised at first sight by the keeper of a menagerie, to whom they were shown, as resembling both in form and appearance the fæces of the spotted Hyæna; and, being analysed by Dr Wollaston, were found to be composed of the ingredients that might be expected in fœcal matter derived from bones, viz. phosphate of lime, carbonate of lime, and a very small proportion of the triple phosphate of ammonia and magnesia. This discovery of the coprolites of the hyæna formed, perhaps, the strongest of the links in that chain of evidence by which Dr Buckland proved that the cave at Kirkdale, in Yorkshire, had been, during a long succession of years, inhabited as a den by hyænas, and that they dragged into its recesses the other animal bodies, whose remains, splintered and bearing marks of the teeth of the hyæna, were found mixed indiscriminately with their own.

Viverridæ.

This family of *Carnivora*, which comprehends the Civets, Genets, Ichneumons, Musangs, Surikates, and Mangues, is characterized with few exceptions, by the following formula:—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{2.2}{2.2} = 40,$$

(fig. 106). It differs from that of the genus *Canis* by the absence o a tubercular tooth (*m* 3) on each side of the lower jaw; but, in thus making a nearer step to the feline dentition, the *Viverridæ*, on the other hand, recede from it by the less trenchant and more tubercular character of the sectorial teeth.

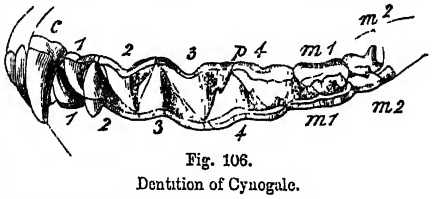

Fig. 106.

Dentition of Cynogale.

The canines are more feeble, and their crowns are almost smooth; the premolars, however, assume a formidable size and shape in some aquatic species, as those of the sub-genus *Cynogale* (fig. 106), in which their crowns (*p* 1-4) are large, compressed, triangular, sharp-pointed, with trenchant and serrated edges, like the teeth of certain sharks, (whence the name *Squalodon*, proposed for one of the species), and well adapted to the exigencies of quadrupeds subsisting principally on fish; the opposite or obtuse, thick form of the premolars is manifested by some of the Musangs, as *Paradoxurus auratus*.

[1] An eminent civil engineer, to whom the writer showed the jaw of a hyæna, observed that the strong conical tooth, with its basal ridge, was a perfect model of a hammer for breaking stones for roads.

[2] "The strength of the hyæna's jaw is such, that in attacking a dog, he begins by biting off his leg at a single snap." Buckland, *Reliquiæ Diluvianæ*, p. 23.

Teeth of Mammals.

In the lower jaw the sectorial tooth (*m* 1) manifests its true molar character by the presence of an additional pointed lobe on the inner side of the two lobes forming the blade at the forepart of the crown; the posterior, low, and large lobe of the tooth being also tuberculate, as in the dog. The last molar (*m* 2) has an oval crown with four small tubercles, resembling the penultimate lower molar in the dog, with which it corresponds.

The deciduous dentition consists, in the Viverrine family, of—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ m\,\frac{3.3}{3.3} = 28.$$

If the first permanent premolar has any predecessor, it must be rudimental, and disappear early in both jaws; the second premolar displaces the first normally developed deciduous molar; the third upper premolar displaces and succeeds the deciduous sectorial, which has a sharper and more compressed blade, and a relatively smaller internal tubercle, than the permanent sectorial. This tooth displaces the last deciduous molar, which is a tubercular tooth, resembling in form the first of the two upper permanent tuberculars; these coming into place without pushing out any predecessors, enter into the category of true molar teeth. In the lower jaw the third premolar displaces the deciduous sectorial, which has three trenchant lobes and a relatively smaller posterior talon than the permanent sectorial. The fourth premolar displaces the third or tubercular milk-molar. The permanent sectorial and tubercular molars displace no predecessors, and are therefore *m* 1 and *m* 2.

The alternate interlocking of the crowns of the teeth of the upper and lower jaws, which is their general relative position in the Carnivora, is well-marked in regard to the premolars of the *Viverridæ* (fig. 106); as the lower canine is in front of the upper, so the first lower premolar (*p* 1) rises into the space between the upper canine and first upper premolar; the fourth lower premolar in like manner fills the space between the third upper premolar (*p* 3) and the sectorial tooth (*p* 4), playing upon the anterior lobe of the blade of that tooth which indicates by its position, as by its mode of succession, that it is the fourth premolar of the upper jaw. The first true molar below, modified as usual in the *Carnivora* to form the lower sectorial, sends the three tubercles of its anterior part to fill the space between the sectorial (*p* 4) and the first true molar (*m* 1) above. In the Musangs, the lower sectorial is in more direct opposition to its true homotype, the first tubercular molar in the upper jaw; and these Indian *Viverridæ* (*Paradoxuri*) are the least carnivorous of their family, their chief food consisting of the fruit of palm-trees, whence they have been called "Palm-cats."

Canis.

The normal dental formula of the genus *Canis* is—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{2.2}{3.3} = 22 \text{ (fig. 107, } \textit{Canis}\text{)}.$$

The incisors form a continuous series, describing the segment of a circle in both jaws, and progressively increase in size from the first

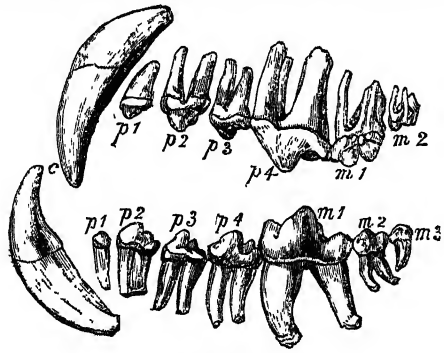

Fig. 107.

Teeth of the Dog.

to the third; the trenchant margin of the crown is divided by two notches into a large middle and two small lateral lobes. The canines (*c*) are curved, sub-compressed; the enamelled pointed crown forms nearly half the length of the tooth, and is smooth, without any groove. The premolars (*p*) have strong sub-compressed conical crowns gradually enlarging from the first to the third (*p* 3) in the upper jaw, and to the fourth (*p* 4) in the lower jaw, and acquiring one or two accessory posterior tubercles as they increase in size. The fourth upper premolar (*p* 4) presents a sudden increase of size, with its sectorial form; its blade is divided into two cones by a wide notch, the anterior cone being the strongest and most produced; the tubercle is developed from the inner side of the base of this lobe. The first and second upper molars (*m* 1 and 2) are tuberculate; but the second is very small, less than half the size of the first molar. The first true molar below (*m* 1) is modified to form the opposing blade to the sectorial tooth above; retaining the tuberculate character at its posterior half. The blade is divided by a vertical lineal fissure into two cones, the posterior being the largest; behind this the base of the crown extends into a broad, quadrate, tuberculate talon. The second molar has two anterior cusps on the same transverse line, and a posterior broad flat talon; the last lower molar (*m*, 3) is the smallest of all the teeth.

Teeth of Mammals.

The absence of a tuberculate molar in the lower jaw of the immature Dog, brings the character of the deciduous dentition of the genus *Canis* much closer to that of the typical members of the Carnivorous order, and affords an interesting illustration of the law that "unity of organization is manifested directly as the proximity of the animal to the commencement of its development."[1] The succession of two tubercular molar teeth behind the permanent sectorial tooth in the adult, or permanent dentition of the lower jaw, carries the genus *Canis* farther from the type of its order, and stamps it with its own proper omnivorous character, and this contributes to adapt the Dog for a greater variety of climates and food, and of other circumstances, all of which tend, in an important degree, to fit that animal for the performance of its valuable services to man. In no other genus of quadruped are the jaws so well or so variously armed with dental organs; notwithstanding the extent of the series, the vacancies are only sufficient to allow the interlocking of the strong canines. These are efficient and formidable weapons for seizing, slaying, and lacerating a living prey: the incisors are well adapted, by their shape and advanced position, for biting and gnawing; the premolars, and especially the sectorials, are made for cutting and coarsely dividing the fibres of animal tissues, and the tuberculate molars are as admirably adapted for cracking, crushing, and completing the comminution of the food, whether of an animal or vegetable nature.

Mustelidæ.

The dentition of the Weasel tribe (*Mustelidæ*) is illustrated in fig. 145, IV., *Mustela*, and by that of the Otter, fig. 108, which is a great aquatic Weasel or Polecat; its dental formula is—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{3.3};\ m\,\frac{1.1}{2.2} = 36.$$

The canines (*c*) are shorter than those of the Fox, narrower than those of the Badger, larger and relatively thicker than those of the Martin-cat. The first premolar (*p* 1) in the upper jaw, which is absent in the Polecat and Weasel, is retained in the Otter (fig. 108 and is placed on the inner side of the canine; the sectorial premolar (*p* 4) has its inner lobe much more developed in *Lutra* than in *Putorius*, and the tubercular molar (*m* 1) is relatively larger. Similar modifications of these teeth distinguish the dentition of the lower jaw of the Otter, which agrees in the number and kind of teeth with that of the Polecat. The increased grinding surface relates to the inferior and coarser nature of the animal diet of the Otter, the back teeth being thus adapted for crushing the bones of fishes before they are swallowed.

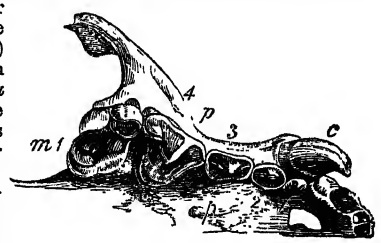

Fig. 108.

Teeth of Upper Jaw of the Otter.

In the Martin cats (*Mustela*), the little homotype of *p* 1 above is present in the lower jaw; in the bloodthirsty Stoats and Weasels, *p* 1 is absent in both jaws; as it is likewise in the great Sea-otter (*Enhydra*), in which also the two middle incisors are wanting in the lower jaw. In this animal the second premolar (*p* 3) has a strong obtuse conical crown, double the size of that of *p* 2; the third premolar (*p* 4) is more than twice the size of *p* 3, and represents the upper carnassial or sectorial strangely modified; the two lobes of the blade being hemispheric tubercles. The last tooth (*m* 1) has a larger crown than the sectorial, and is of a similar broad crushing form.

The *Mustelidæ* present great constancy in regard to the number of their true molar teeth; with one exception, the Ratel (*Mellivora*), in which *p* 2 is absent below, they have one true molar on each side of the upper jaw, and two on each side of the lower jaw; the second of these has always a broad tubercular crown, like the one above. The upper true molar is supported by one inner, and sometimes by one (*Putorius, Gulo*), sometimes two (*Mustela, Lutra, Melphitis*) outer fangs. The second true molar below is also tubercular, but has a single fang. The crown of the first true molar below offers many gradations from the sectorial type, as manifested in *Putorius* and *Gulo*, to the tubercular type, as in the Taira, Ratel, and Sea-otter. The principal varieties occur, as usual, in the comparatively less important premolars; in the Martins and Gluttons, they are as numerous as in the Dog; the first, in both jaws, being implanted by a single fang; the rest by two, with the exception of the last above, which has three roots. In the Otter, we find the first premolar removed from the lower jaw; and the second (now the first) shows its true homology by its double implantation, as well as by the position of its crown behind the first in the upper jaw.

[1] This law is defined and exemplified in the writer's *Lectures on the Invertebrate Animals*, pp. 368, 800, ed. 1843; p. 645, ed. 1855.

Teeth of Mammals.

In the Stoats, Skunks, and Ratels, the premolar series is further reduced by the loss of the anterior tooth (p 1) in both jaws, and by the diminution of the size of p 2, which thus becomes the first in both jaws, and is also now implanted by a single fang. In a South American Skunk, the second premolar disappears in the upper jaw, leaving there only the homologues of the third and fourth of the typical formula, p 4 being always the sectorial in the *Mustelidæ*, as in other terrestrial Carnivora. This tooth, under all its modifications, retains the blade with the lobe, corresponding to the middle one in the feline sectorial, generally well-developed and sharp-pointed; the differences are principally manifested by the proportions of the inner tubercle, and the relative size of the third root supporting it. But the upper sectorial, being a premolar, and therefore requiring less modification of the crown to adapt it for its special functions, manifests a more limited extent of variety than the lower sectorial, which, being a true molar, requires greater modification of the typical form of its crown to fit it for playing upon the sectorial blade of p 4 above.

Melidæ.

In this sub-family is comprised the European Badger (*Meles*), the Indian Badger (*Arctonyx*), and the American Badger (*Taxidea*); which, with respect to their dentition, stand at the opposite extreme of the *Mustelidæ* to that occupied by the predaceous Weasel, and manifest the most tuberculate and omnivorous character of the teeth. The formula is—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3\,3}{4.4};\ m\,\frac{1.1}{2\,2} = 30.$$

The canines are strongly developed, well pointed, with a posterior trenchant edge; they are more compressed in *Arctonyx* than in *Meles*. The first lower premolar (p 1) is very small, single-fanged, and, generally, soon lost. The first above, corresponding with the second in the dog, is also small, and implanted by two connate fangs. The second upper premolar (p 3) has a larger, but simple, sub-compressed conical crown, and is implanted by two fangs. The third (p 4) repeats the form of the second on a larger scale, with a better developed posterior talon, and with the addition of a trituberculate low flat lobe, which is supported by a third fang; the outer pointed and more produced part of this tooth represents the blade of the sectorial tooth and the entire crown of the antecedent premolars. The true molar in *Meles* (m 1) is of enormous size compared with that of any of the preceding Carnivora; it has three external tubercles, and an extensive horizontal surface traversed longitudinally by a low ridge. and bounded by an internal belt, the "cingulum" of Illiger. In the Labrador Badger, the last premolar has a larger relative size, the part corresponding with the blade of the sectorial is sharper and more produced, and the internal tubercle has two lobes; the succeeding molar tooth is reduced in size, and its crown presents a triangular form. The first true molar below has its sectorial lobes better developed; these differences give the North American badgers a more carnivorous character than is manifested by the Indian or European species.

Procyonidæ.

In other allied genera, which, like the badgers, have been grouped, on account of the plantigrade structure of their feet, with the bears, a progressive approximation is made to the type of the dentition of the Ursine species. The first true molar below soon loses all its sectorial modification, and acquires its true tubercular character; and the last premolar above becomes more directly and completely opposed to its homotype in the lower jaw. The Racoon (*Procyon*), and the Coati (*Nasua*), present good examples of these transitional modifications; they have the complete number of premolar teeth, the dental formula being,

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{2.2}{2.2} = 40.$$

The development of the inner part of the crown of the last upper premolar, which constitutes the tubercle of the sectorial tooth, now produces two tubercles on a level with the outer ones which represent the blade; and the opposite premolar below (p 4), which is the true homotype of the modified sectorial above, begins to acquire a marked increase of breadth and accessory basal tubercles. All the lower premolars, as well as the true molars, have two fangs; the three first premolars above have two fangs, the fourth has three, like the two true molars above.

The dental formula of the Indian Benturong (*Arctictis*) and Kinkajou (*Cercoleptes*) is—

$$i\,\frac{3\,3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{2.2}{2.2} = 36.$$

Ursidæ.

The essential characteristic of the dentition of the Bears (figs. 109 and 145, II.), *Ursus*, is the development, in the lower jaw, of the true molar teeth to their typical number in the placental *Mammalia*, and their general manifestation, in both jaws, of a tuberculate grinding surface; the premolar teeth are much reduced both in size and number. In the frugivorous Bears of India and the Indian Archipelago, the four premolars (p 1-4) are commonly retained longer than in the fiercer species of the northern latitudes. In the *Ursus labiatus*, the third small premolar above, and the second and third below, have each two connate fangs; the fourth premolar above presents three sub-equal obtuse tubercles supported by two distinct fangs. It is the only one of the four lower premolars retained in the dentition of the great extinct *Ursus spelæus;* the first premolar co-exists with it in the *Ursus priscus*, as also commonly in the *U.* Teeth of Mammals.

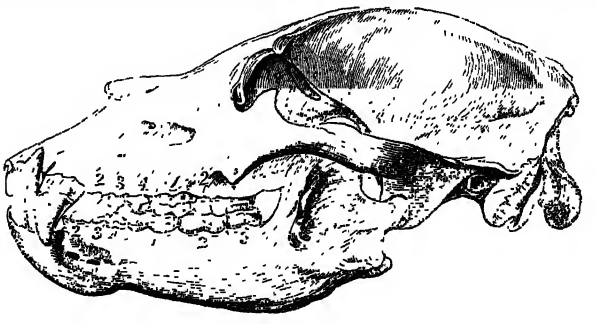

Fig. 109.
Dentition of the Bear (*Ursus*).

maritimus and *U. arctos*. The second lower premolar is soon lost in the Bears of temperate and northern latitudes, but is longer retained in the tropical species called "Sun Bears" (*Helarctos*, Horsefield). The first true molar (m 1) has a longer and narrower crown than the one above. The second true molar (m 2) has a narrow, oblong, subquadrate, tubercular crown, which, like that of the first true molar, is supported by two fangs. The crown of the third lower molar (m 3) is contracted posteriorly, and supported by two connate fangs; it is relatively smallest in the Sun-bears, and largest in the great *Ursus spelæus*. The dental formula of the genus Ursus is—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{2.2}{3.3} = 42.$$

It is essentially the same both in number and kind of teeth as in genus *Canis*, but the individual or specific varieties, which in the Dog affect the true molar teeth, are confined in the Bears to the premolars. It would seem in the genus *Ursus* as if the preponderating size of the large tubercular true molars had tended to blight the development of the premolars.

In fig. 110 the deciduous teeth and their successors are figured,

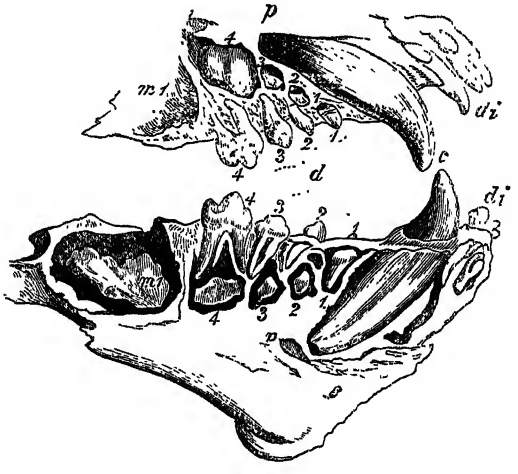

Fig. 110.
Milk-Teeth of the Bear.

as displayed by the removal of the outer wall of their sockets. The milk-molars, four in number on each side of both jaws, progressively increase from the first to the fourth. The characteristic relative position to them of the premolars is shown at p 2, 3, and 4. Behind these is shown the large formative cell of the first (m 1) of the true molar series.

Phocidæ.

A tendency to deviate from the ferine number of the incisors is seen in the most aquatic and piscivorous of the Musteline quadrupeds, viz., the Sea-otter (*Enhydra*), in which species the two middle incisors of the lower jaw are not developed in the permanent dentition. In the family of true seals the incisive formula is further reduced, in some species even to zero in the lower jaw, and it never exceeds $\frac{3}{2}.\frac{2}{2}$. All the *Phocidæ* possess powerful canines; only in the aberrant walrus (fig. 112), are they absent in the lower jaw, but this is compensated by the singular excess of development which they manifest in the upper jaw,

In the pinnigrade, as in the plantigrade, family of Carnivores, we find the teeth which correspond to true molars more numerous than in the digitigrade species, and even occasionally rising to the typical number, three on each side; but this, in the seals, is manifested in the upper, and not, as in the bears, in the lower jaw. The entire molar series usually includes five, rarely six, teeth on each side of

Teeth of Mammals.

the upper jaw, and five on each side of the lower jaw; with crowns which vary little in size or form in the same individual. They are supported in some genera, as the Eared Seals (*Otariæ*) and Elephant Seals (*Cystophora*), by a single fang; in other genera by two fangs, which are usually connate in the first or second teeth; the fang or fangs of both incisors, canines, and molars, are always remarkable for their thickness, which commonly surpasses the longest diameter of the crown. The crowns are most commonly compressed, conical, more or less pointed, with the "cingulum" and the anterior and posterior basal tubercles more or less developed; in a few of the largest species they are simple and obtuse, and particularly so in the walrus, in which the molar teeth are reduced to a smaller number than in the true seals.[1] In these the line of demarcation between the true and false molars is very indefinitely indicated by characters of form or position; but, according to the instances in which a deciduous dentition has been observed, the first three permanent molars in both jaws succeed and displace the same number of milk molars, and are consequently *premolars;* occasionally, in the seals with two-rooted molars, the more simple character of the premolar teeth is manifested by their fangs being connate, and in the *Stenorhynchus serridens* (fig. 111) the more complex character of the true molars (*m* 1 and 2) is manifested in the crown. There is no special modification of the crown of any tooth by which it can merit the name of a "sectorial" or "carnassial;" but we may point with certainty to the third molar above and the fourth below, as answering to those teeth which manifest the sectorial character in the terrestrial Carnivora.

The coadaptation of the crowns of the upper and lower teeth is more completely alternate than in any of the terrestrial Carnivora, the lower tooth always passing into the interspace anterior to its fellow in the upper jaw.

In the genus *Phoca* proper (*Calocephalus*, Cuv.) typified by the common seal (*Ph. vitulina*), the dental formula is—

$$i\,\frac{3.3}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{3\,3}{3.3};\ m\,\frac{2\,2}{2.2} = 34.$$

In the *Phoca Caspica* the upper molars have commonly one accessory cusp before, and one behind, the principal lobe; the lower molars have one accessory cusp before, and two behind, the lower molars.

In the *Phoca Grœnlandica* the upper molars have no anterior basal cusp, and only one behind; the lower molars have two behind and one in front, except the first, which resembles that above, and like it has connate fangs.

The condition of the molar teeth is nearly the same in the *Phoca barbata*, but the crowns are rather thicker and stronger, and the three middle ones above have two posterior basal cusps feebly indicated, the same being more strongly marked in the four last molars below.

The following genera of Seals with double-rooted molars (*Pelagius*, *Stenorhynchus*) have four incisors above as well as below, *i.e.* $\frac{2\cdot2}{2\cdot2}$.

The allied sub-genus (*Ommatophoca*) of Seals of the southern hemisphere has six molar teeth on each side of the upper, and five on each side of the lower jaw, with the principal lobe of the crown more incurved. The two first molars above are closely approximated, but this may prove to be a variety.

In the *Stenorhynchus* the jaws are more slender and produced, and the molar teeth are remarkable for the long and slender shape of the principal lobe, and of the accessory basal cusps. The incisors

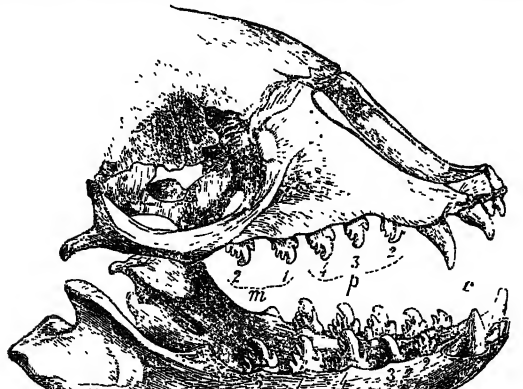

Fig. 111.

Dentition of the Saw-toothed Seal. (*Stenorhynchus*).

(fig. 111) have sharp conical recurved crowns, like the canines, and the external ones in the upper jaw are intermediate in size between the canines and the middle incisors.

Teeth of Mammals.

In the *Stenorhynchus leptonyx* each molar tooth in both jaws is trilobed, the anterior and posterior accessory lobe curving towards the principal one, which is bent slightly backwards; all the divisions are sharp-pointed, and the crown of each molar thus resembles the trident or fishing-spear; the two fangs of the first molar in both jaws are connate. In *Stenorhynchus serridens* (fig. 111), the three anterior molars on each side of both jaws are four-lobed, there being one anterior and two posterior accessory lobes; the remaining posterior molars (true molars) are five-lobed, the principal cusp having one small lobe in front, and three developed from its posterior margin; the summits of the lobes are obtuse, and the posterior ones are recurved like the principal lobe. Sometimes the third molar below has three instead of two posterior accessory lobes. Occasionally, also, the second, as well as the first molar above, has its fangs connate; but the essentially duplex nature of the seemingly single fang, which is unfailingly manifested within by the double pulp-cavity, is always outwardly indicated by the median longitudinal opposite indentations of the implanted base. These slight and unessential varieties, presented by the specimens of the Saw-toothed Sterrink (*Stenorhynchus serridens*) brought home by the enterprizing naturalist of Sir J. Ross' Antarctic expedition, accord with the analogous varieties noticed in other species of Seals, and show the inadequacy of such characters as marks of subgeneric distinction.

In the genus *Otaria* the dental formula is—

$$i\,\frac{3.3}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{2.2} = 36.$$

The two middle incisors are small, sub-compressed, with the crown transversely notched; the simple crowns of the four incisors below fit into these notches; the outer incisors above are much larger, with a long-pointed conical crown, like a small canine. The true canine is twice as large as the adjoining incisor, and is rather less recurved. The molars have each a single fang.

In the great proboscidian and hooded Seals (*Cystophora*), the incisors and canines still more predominate in size over the molars; but the incisors are reduced in number, the formula here is—

$$i\,\frac{2.2}{1.1};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{2.2}{2.2} = 30.$$

All the molars are single-rooted, and all the incisors are laniariform. The two middle incisors above and the two below are nearly equal; the outer incisors above are larger. The canines are still more formidable, especially in the males; the curved root is thick and subquadrate. The crowns of the molar teeth are short, sub-compressed, obtuse; sometimes terminated by a knob and defined by a constriction or neck from the fang; the last is the smallest.

In the Walrus (*Trichechus rosmarus*, fig. 112), the normal incisive formula is transitorily represented in the very young animal, which has three teeth in each intermaxillary bone and two on each side of the forepart of the lower jaw; they soon disappear, except the outer pair above, which remain close to the intermaxillary suture, on the inner side of the sockets of the enormous canines, and seem to commence the series of small and simple molars which they resemble in size and form. In the adult there are usually three molars or premolars on each side, behind the permanent incisor, and four similar teeth on each side of the lower jaw; the anterior one passing into the interspace between the upper incisor and the first molar, and therefore being the homotype of the molar. In a young walrus' skull with canine tusks eight inches long, the writer has seen a fourth upper molar (fifth including the incisor) of very small size, about a line in breadth, lodged in a shallow fossa of the jaw, behind the three persistent molars. The crowns of these teeth must be almost on a level with the gums in the recent head; they are very obtuse, and worn obliquely from above down to the inner border of their base. The molars of the lower jaw are rather narrower from side to side than those above, and are convex or worn upon their outer side. Each molar has a short, thick, simple and solid root.

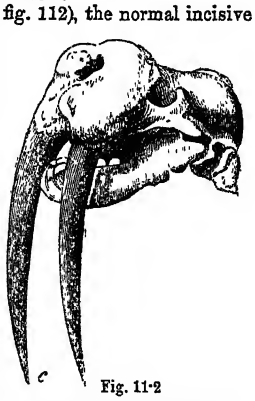

Fig. 112

Skull and Teeth of the Walrus

The canines (*c*) are developed only in the upper jaw, but are of enormous size, descending and projecting from the mouth, like tusks, slightly inclined outwards and bent backwards; they present an oval transverse section, with a shallow longitudinal groove along the inner side, and one or two narrower longitudinal impressions upon the outer side; the base of the canine is widely open, its growth being uninterrupted.

The food of the walrus consists of sea-weed and bivalves; the

[1] The relation of *Trichechus* to the *Phocidæ* is analogous to that of *Machairodus* to the *Felidæ*, and also, in the simplification of the molars, to that of *Proteles* to the *Canidæ*.

Teeth of Mammals.

molars are well adapted to break and crush shells; and fragments of a species of *Mya* have been found, with pounded sea-weed, in the stomach. The canine tusks serve as weapons of offence and defence, and to aid the animal in mounting and clambering over blocks of ice.

Machairodus.

A large extinct carnivorous animal (*Machairodus*, fig. 145, VI.), had the upper canine teeth (*c*) developed to almost the same disproportionate length as in the walrus, by which they were also compelled to pass outside the lower jaw when the mouth was shut. But these teeth were shaped after the type of the feline canines, only with more compressed and trenchant crowns; and they were associated with other teeth in number and kind demonstrating the due affinity of the *Machairodus* to the genus *Felis*.

The molar series of the upper jaw includes three teeth on each side, answering to the last two premolars (*p* 3 and *p* 4) and to the small tubercular tooth (*m* 1) in the lion The inner tubercle of the carnassial tooth (*p* 4) is much less developed than in *Felis*. The molar series of the lower jaw accords with that of the lion, but *p* 3 is relatively very small in the South American *Machairodus* (*M. neogœus*).

The symphysis of the lower jaw presents a rapid increase in vertical diameter, whilst a depression on the outer side, between the canine and the first molar, indicates the part which received the long upper canine. The lower canine is much reduced in size, and appears to form the exterior tooth of the series of incisors; these are, however, six in number in the lower as in the upper jaw.

Both the anterior and posterior margins of the long upper falciform canines are finely serrated in *Machairodus*. The fossil teeth of this kind from Kent's Hole, Torquay, indicate a species of *Machairodus*, as big as the lion, and distinct from that of the Italian pliocene deposits, on which Cuvier founded his "*Ursus cultridens*."

Hyænodon.

In more ancient tertiary formations, remains of carnivorous mammals have been found with the three true molar teeth as expressly modified for the division of flesh, and as worthy the express term of "sectorials" or "carnassials," as the teeth so called in the lion and other felines. And these teeth were associated with conical premolars, long canines, and short incisors, so as to exemplify the typical formula, *e. g.*—

$$i\,\tfrac{3.3}{3.3};\ c\,\tfrac{1.1}{1.1};\ p\,\tfrac{4.4}{4.4};\ m\,\tfrac{3.3}{3.3} = 44.$$

The extinct *Hyænodon* and *Pterodon* of the upper eocene formations of Hampshire, and of parts of France, manifest this interesting and instructive character of dentition.

A reduced view of the lower jaw of the *Hyænodon Requieni* is given in fig. 113. After the canines (*c*) come four successively

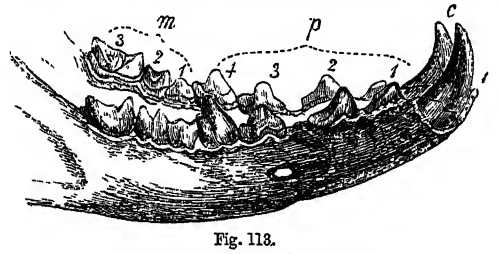

Fig. 113.

Dentition, Lower Jaw, of *Hyænodon*.

enlarging conical compressed premolars (*p* 1-4); then, instead of a single carnassial representing the first true molar, there are three of these singularly modified teeth—the first (*m* 1) being of suddenly small size, as compared with the antecedent premolar, and obviously illustrating its true nature as a continuation of the deciduous series, with which, doubtless, it agreed in size. It became a permanent tooth only because there was no premolar developed beneath it, so as to displace it. The succeeding carnassial true molars (*m* 2 and 3) progressively increase in size. The symbols in fig. 111 denote the homologies of the teeth. The marks of abrasion on the lower teeth

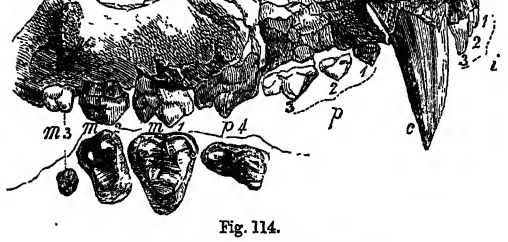

Fig. 114.

Dentition, Upper Jaw, of *Amphicyon*.

in the *Hyænodon* prove the upper series to have been the same in number.

The obvious number of premolars in the *Hyænodon* negatives the notion entertained by De Blainville, that it was a marsupial carnivore. Teeth of Mammals.

Amphicyon.

A second form of equally ancient Carnivore was a mixed-feeding animal, allied to the Viverridæ and to the Dog tribe, the true molars presenting the tuberculate modification, and the typical number and kinds of teeth being functionally developed, as in the *Hyænodon*. The series in the upper jaw are shown in fig. 112. The term "tubercular" is as applicable to the three true molars of the *Amphycyon* (*m* 1, 2, 3) as the term "carnassial" is to those of the *Hyænodon*.

Structure Carnivora.

The teeth of the *Carnivora*, with the exception of the aberrant amphibious forms, so closely correspond in their intimate structure, both with each other and with those of the human subject, as to require here only a brief and general notice. They all enter into the category of "simple teeth," that is, the dentine or main body is not penetrated by folds of the other component tissues, but has an even exterior, covered, at the part forming the crown, with enamel, and having a general outer investment of cement, the coronal layer forming too thin a film to manifest any of the radiated cells. The dentine is of the kind called "hard or unvascular;" the tubuli are rather finer than in the human teeth; they have the same general direction from the pulp-cavity, but present stronger primary curvatures, more frequent dichotomous divisions, and more numerous minute lateral branches, which latter usually curve from the trunks at right angles. The dentinal compartments are subhexagonal, about $\frac{1}{3000}$th of an inch in diameter, with the peripheral contour forming almost a regular curve. In the Seals the dentine forms usually a smaller proportion of the tooth than in the terrestrial *Carnivora;* the characteristic thickness of the roots in this family is principally due to the thick covering of cement, and the pulp-cavity is usually closed by a more than usual quantity of the osteo-dentine. The tubes in the Seal's molar describe very strong and irregular curves on leaving the pulp-cavity; but when within a third of the distance to outer surface, they fall into more parallel and regular undulations; they are $\frac{1}{1300}$th of an inch in diameter, and the interspace between two tubes is about $\frac{1}{10000}$th of an inch in width.

The tubes dichotomise less frequently and less regularly than in the teeth of the Dog or Hyæna, but send off from both sides extremely numerous short branches, which bend almost transversely across the interspaces, and the side branches are occasionally sent off in greater abundance along lines parallel with the outer contour of the teeth, giving the appearance of opaque striæ, or concentric layers, to polished sections of the dentine. The dentinal tubes resolve themselves at their extremities into rich tufts of curved branches, which terminate in a layer of minute cells at the crown, and in the root communicate with the radiated cells of the cement.

In the molar teeth of the *Otaria jubata*, the tubes, proceeding in the long axis of the crown, are, on the peripheral half of the dentine, nearly parallel; towards the side of the crown they proceed in more zigzag, almost angular curves, and appear to cross each other, conspicuous branches being continued from the angles; the interspaces of the tubes were about $\frac{1}{4000}$th of an inch in width. The dentinal compartments are more numerous and less regular than in the teeth of the ordinary *Carnivora;* and their contour is more obscured by the deeper curves and more numerous branches of the dentinal tubes.

The enamel of the teeth of the *Carnivora* is extremely dense and brittle; it consists of fibres similar to those in the Human teeth, but relatively smaller, as, for example, in the large canines of the Tiger, and the molars of the Hyæna; the transverse striæ are also less distinct. In the molar of the *Otaria*, the enamel-fibres are very distinct, placed at right angles to the plane of the crown, and less curved than in Man or the Quadrumana; instead of the transverse striæ, they present a minute granular structure.[2]

The cap of enamel with which the teeth of the Walrus are at first tipped, is soon worn off; and, except at the abraded surface, the rest of the tooth—both tusks and molars—is thickly coated with cement. The dentine closely corresponds with that in the ordinary Seals; in the molar teeth the tubes present the same diameter, the same interspaces, and undulating curvatures; but their dichotomous divisions are more marked. In the canines the lateral branches terminate in minute opaque cells, dispersed throughout almost the whole dentine, but most numerous and conspicuous near its periphery, where the dentine is defined by a distinct layer of these cells; only a third part of the periphery of the canine is composed of true dentine, the central third part of the tooth is filled up by osteo-dentine, which, as in the teeth of the Cachalot, often projects in irregular rounded masses into the short and wide basal pulp-cavity. The whole mass, indeed, of the osteo-dentine consists of numerous independent calcifications of the pulp, having as many distinct centres, usually hollow, and producing, when the substance is examined by the naked eye, the appearance which Cuvier has compared to "pudding-stone." The central cavities are for the most part associated together and with the pulp-cavity by medullary canals. The tubes radiate from these central cavities in all directions, with sub-parallel, diverging curva-

[1] *Ossemens Fossiles*, 4to, 1824, vol. v. pt. ii. p. 517.

[2] Retzius failed to detect any true enamel in the teeth of the *Phoca anellata*.

Teeth of Mammals.

tures, dividing, subdividing, and sending off numerous branches, which anastomose with those of the adjoining masses, and, where these are situated next the dentine, with the tubes of that tissue. In each lobe of the osteo-dentine the concentric rings parallel with the contour of the central medullary cavity are well marked. Myriads of minute calcigerous cells are dispersed throughout the osteo-dentine. The pulp-cavity of the incisor and molar teeth is filled up by a smaller quantity of the osteo-dentine.[1] Minute vascular canals convey the capillary blood-vessels to this structure, from the vascular membrane attached to the solid base of the molars, and in the tusks, from the persistent pulp, which fills the basal cavity.

The cement of the Morse's teeth is distinguished from the osteo-dentine by its continuous uniform structure, by the absence of the detached centres, and their concentric lines; but the radiated cells are disposed in regular layers, concentric and parallel with the contour of the body of dentine; the radiating tubes, from the cells forming the layer next the dentine, communicate freely with the peripheral ramifications of the dentinal tubes, and also with the proper cemental tubes, which are disposed vertically to the plane of the cement. Indeed, the evidence of an intercommunicating system of canals, too minute for the gross fluid of the circulating system, is most striking and universal throughout the substance of both the tusks and small teeth of the Walrus. Vascular canals are, however, present in the cement as in the osteo-dentine, from the capillaries in which it may be presumed that the colourless plasma is elaborated, which meanders through the minuter systems of cells and tubes.

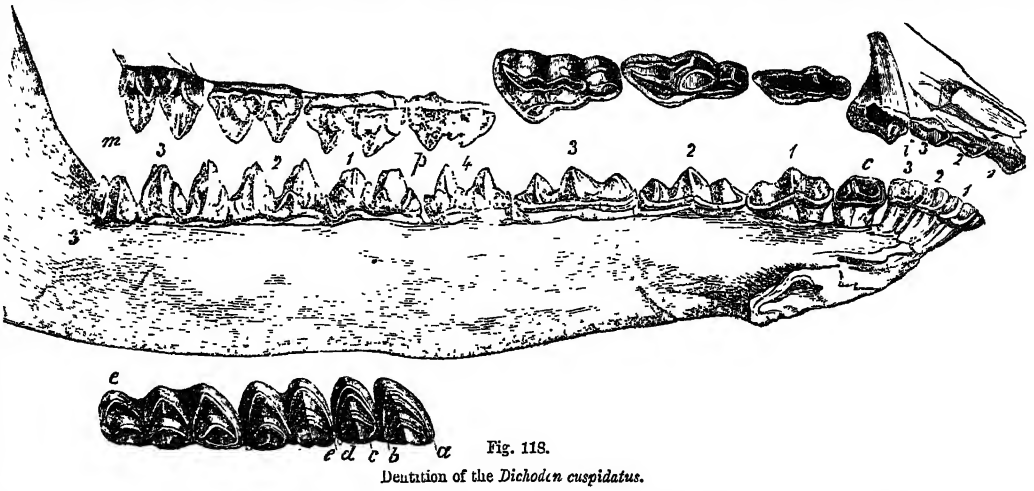

Fig. 118.
Dentition of the *Dichodon cuspidatus*.

Ungulata, or Herbivora.

The first forms of vegetable-eating mammals of which we have cognizance, those, viz., that have been restored from fossil remains discovered in the eocene or oldest tertiary deposits, have presented a dentition conformable, in number and kind of teeth, to the typical condition in the Placental Diphyodont series.

Fig. 115.
Upper Molar of *Hyracotherium*.

Transitional modifications of the molar teeth

The chief modifications are presented by the grinding surface of the molar teeth. In the *Hyracotherium* (*e. g.*, fig. 115) the grinding surface supports four principal cusps, each transverse pair (*a c*, *b d*) being connected by a ridge which is raised midway into a smaller conical tubercle, and the crown is girt by a cingulum.

In the Anoplotherium (fig. 116) the crown is divided into a front (*f*, *c*) and a back (*f*, *d*) lobe by a valley (*e*), extending from the inner side, two-thirds across, contracting as it penetrates. A second valley (*g*, *i*) crosses its termination at right angles, and forms a curved depression in each lobe, concave towards the outer side of the crown,—this side being impressed by two parallel excavations (*f f*). There is a large conical tubercle (*m*) at the wide entry of the valley (*e*).

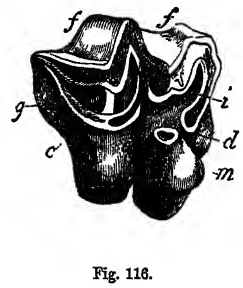

Fig. 116.
Upper Molar of *Anoplotherium*.

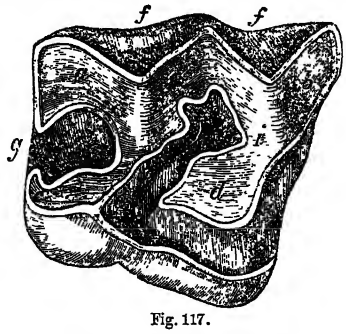

Fig. 117.
Upper Molar of *Palæotherium*.

The two points of the outer continuous border formed by the two outer lobes (*o*, *v*) are first abraded; those of the inner lobes (*c*, *d*) are next abraded; and thus a double crescentic field of dentine is exposed, with a detached island on the summit of the internal cone (*m*). This, afterwards, from the minor depth of the valley in front of its base, becomes blended with the lobe (*d*). In the *Palæotherium* (fig. 117) the crown of the molar is divided into an anterior (*b*, *d*) and posterior (*a*, *c*) part by an oblique fissure (*e*), continued from near the middle of the inner surface of the crown obliquely outwards and forwards. two-thirds across the tooth. Each division is subdivided partially into two outer (*a* and *b*) and two inner (*c* and *d*) lobes; the anterior division by the terminal expansion (*i*) of the fissure (*e*), the posterior one by the valley or fissure (*g*). The lobes (*c* and *d*) are bordered near their base by a ridge.

The first of the above types (fig. 115) of the upper grinders of the eocene *Herbivora* is continued into, or governs, with minor modifications, the corresponding teeth of the *Chœropotamus*, *Anthracotherium*, and the existing Hog-tribe and Hippopotamus. The second or Anoplotherian type (fig. 116) is continued into the *Dichodon*, *Dichobunes*, and the existing Ruminant dentition. The third (fig. 117) is the fundamental pattern of the upper molars of the tribes of the Horse and Rhinoceros.

A fourth form of eocene grinder, that of the genus *Lophiodon*, is very nearly allied to the *Palæotherium*, but the more complete union of the lobes *a*, *c*, and that of the lobes *b*, *d*, gives a more decided transversely-ridged character to the crown, and this type was carried on in the Dinotherium (fig. 136) and the existing Tapirs.

The space allotted to this article limits the selection of examples of the ungulate dentition to a few of the best-marked modifications, and the first of these forms a transitional step between the *Anoplotherium* and the *Ruminantia*.

The dentition in question is that of an extinct genus, the remains of which occur in the upper eocene of Hampshire, and which the writer has described under the name of *Dichodon cuspidatus*[2] (fig. 118). The dental formula is—

$$i\,\tfrac{3.3}{3.3};\ c\,\tfrac{1.1}{1.1};\ p\,\tfrac{4.4}{4.4};\ m\,\tfrac{3.3}{3.3} = 44.$$

The crowns of these different kinds of teeth are of nearly equal height, and there is no break in the series.

The incisors (*i* 1, 2, 3) have low and broad trenchant crowns. The canine (*c*) closely resembles them, but is a little larger, and with a low point: it is, however, more trenchant than piercing. The first (*p* 1), second (*p* 2), and third (*p* 3) premolars, have their crown much extended from before backwards, with three progressively more developed and pointed compressed cusps on the same line; to which is added, in the upper jaw, an inner ridge, developed in the third premolar (*p* 3) into an inner posterior cusp. The fourth premolar (*p* 4) has a thicker and shorter crown with two pairs of cusps. The upper true molars (*m* 1, 2, 3) have the two pairs of cusps sharp and pointed, with a series of five low accessory points developed from the outer part of the cingulum. The lower molars (*m* 1, 2, 3) have as complex crowns as the upper ones, but with the accessory basal points (*a*, *b*, *c*, *e*) developed from the inner, instead of the outer side of the crown, and with the convex sides of the chief cusps turned in the opposite direction to those above. In fig. 116 the outer side of the true molars, of the last premolar, of the canine, and of the incisors, is shown, together with the grinding surface of the three anterior premolars in the upper jaw. The inner surface of the

[1] "L'ivoire des défenses du Morse est compact, susceptible d'un poli presque ausi beau que celui de l'hippopotame mais sans stries; la partie moyenne de la dent est formée de petits grains ronds placés pêle mêle, comme le Cailloux dans la pierre appelée *Poudingue*; c'est ce qui le caractérise. Les dents molaires de cet animal ont leur axe composé des mêmes petits grains que celui des défenses. Elles n'ont aucun cavité dans leur interieur."—*Cuvier, Leçons d'Anat. Comparée*, tom. iii. (1805), p. 106.

[2] *Quarterly Journal of the Geological Society*, June 1847.

Teeth of Mammals.

entire series of the lower teeth is shown, together with the grinding surface of the three true molars of the last (*m* 3) here supports a third pair of lobes (*e*) As compared with the anoplotherian molar (fig. 116), the outer lobes (*a*, *b*) of that of the *Dichodon* (fig. 119) are thicker and sharper; the inner ones (*c*, *d*)—especially the latter—are developed to an equality with the outer ones, and more distinctly separated from them. The valley (*m*) extends across the whole breadth of the tooth, and is crossed at right angles by the fore-and-aft doubly-curved valley (*g* and *i*)

Order Ruminantia.

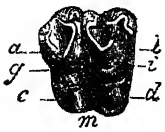

Fig 119.
Upper Molar of *Dichodon*.

The modification of the upper molars of the existing Ruminant quadrupeds consists in the lower and less pointed lobes of the crown, the unworn summits of which are at first rather trenchant, like curved blades, than piercing. They are soon abraded by mastication, and present the crescentic lobes of dentine (*a*, *b*, *c*, *d*) shown in fig. 120. The transverse double-crescentic valley (*g*, *i*) contains a thicker layer of cement, and forms two detached crescents in worn teeth. The premolars resemble in structure one half of the true molars. The upper incisors, the upper canine, and the first premolar of both jaws, are not developed in the typical Ruminants, the dental formula of which is—

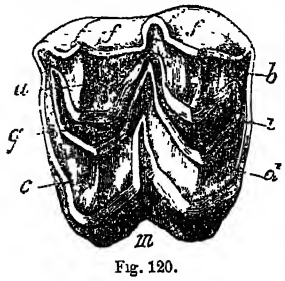

Fig. 120.
Upper Molar of Megaceros.

$$i\ \frac{0\,0}{3.3};\ c\ \frac{0.0}{1.1};\ p\ \frac{3\,3}{3.3};\ m\ \frac{3.3}{3.3} = 32.$$

The gazelle, the sheep, the ox—respectively representing the families *Antilopidæ*, *Ovidæ*, and *Bovidæ*, which are collectively designated the "hollow-horned ruminants"—all present this formula. It likewise characterises many of the solid-horned ruminants, or the deer tribe (*Cervidæ*), the exceptions having canine teeth in the upper jaw of the male sex, and sometimes also in the females, though they are always smaller in these.

The upper canines attain their greatest length in the small ruminants called Musk-deer, and especially in the typical species (*Moschus moschiferus*, fig. 145, VII.) These teeth, indeed, in the male Musk present proportions intermediate between those of the upper canines of the Machairodus and of the Morse. The inverse relationship in the development of teeth and horns, exemplified by the total absence of canines in the Ruminants with persistent and typical horns, by their first appearance in the periodically hornless deer, and their larger size in the absolutely hornless Musks, is further illustrated by the presence not only of canines, but of a pair of laniariform incisors in the upper jaw of the Camelidæ.

Camelidæ

In the Camel and Dromedary the upper canines are formidable for their size and shape, but do not project beyond the lips like the tusk of the Musk-deer; they are more feeble in the Llamas and Vicugnas, and are always of smaller size in the females than in the males. The inferior canines, moreover, retain their laniariform shape in the *Camelidæ*, and are more erect in position than in the ordinary Ruminants. They are separated by a short diastema from the incisors in the *Auchenia*.

The true nature of the corresponding canines in the ordinary Ruminants, in which they are procumbent, and form part of the same series with the incisors, is always indicated by the lateness of their development, and often by some peculiarity of form. Thus in the *Moschus* (fig. 145, VII. *c*) they are smaller and more pointed than the incisors, and in the Giraffe they have a much larger crown, which is bilobed. The laniariform tooth in the premaxillary bone of the *Camelidæ*, which represents the upper and outer incisor, is smaller than the true canine which is placed behind it in the Camel and Dromedary; but in the Vicugna it is as large as, or larger than, the true canine.

Development.

Most of the deciduous molars of the Ruminants resemble in form the true molars; the last milk-molar, for example (fig. 121, *d* 4), in the lower jaw, has three lobes like the last lower true molar (*m* 3). The deciduous molars in existing true Ruminants are three in number on each side, and, being succeeded by as many premolars, the ordinary permanent molar formula is—

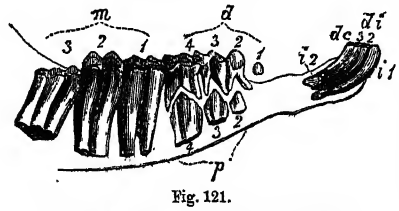

Fig. 121.
Deciduous and Permanent Teeth of a Sheep.

$$p\ \frac{3.3}{3.3};\ m\ \frac{3.3}{3.3};$$

but there is a rudiment of *d* 1 in the embryo fallow-deer, and in one of the most ancient of the extinct Ruminants (*Dorcatherium*, Kaup) the normal number of premolars was fully developed.

Teeth of Mammals.

The birth and growth of a young Giraffe at the Zoological Gardens of London, enabled the writer to make the following observations on the course of development and succession of the teeth in this Ruminant, which is the largest existing species of its order. The four middle deciduous incisors began to cut the gum one week after birth, and their crowns were entirely extricated at the end of four weeks, at which time the summit of the crowns of both the first and second deciduous molars were visible. At two months the third incisor had cut the gum; at three months the third deciduous molar, and at four months a fourth molar were in place; the latter being the first of the permanent series of true molars.

The progress of shedding the deciduous teeth was traced by observation of the mother Giraffe. She arrived at the Zoological Gardens in May 1836, and was then about eighteen months old, and had all the deciduous series, with the first permanent true molars. The two middle deciduous incisors were shed in the month of March 1838, the second incisor on each side in the following July, the first deciduous molars in October, and the second deciduous molars in November and December of the same year. At this time the second true molars came into place, the last true molars began to appear above the gum in August 1839, and the last deciduous molar was replaced by the third premolar before the end of that year. The shedding of the whole deciduous series was completed by the fall of the canines in the female Giraffe at the period of the birth of her second fawn in May 1841, when she must have been six years and a half old; the large bilobed crowns of the permanent canines were not completely in place until September 1841.

The same noble menagerie has afforded the opportunity of recording the following state of the first dentition of the *Dromedary*:—

In the new-born animal the six deciduous upper incisors present a larger size than any rudiments of these that have been discerned in the fœtus of ordinary Ruminants, and, as was discovered by subsequent dissection, these transitory incisors leave conspicuous alveoli in the premaxillary bones. The canine and first functional deciduous molar are small; the second and third deciduous molars are large, bilobed, and each lobe is bicrescentic. In the lower jaw the functional milk-teeth consist of the six incisors and two canines, one on each side, all with the overlapping leaf-shaped crowns. The functional molars are but two in number, in each ramus of the jaw. The first small, simple, conical, compressed, notched behind; the second very large, and three-lobed, each lobe bicrescentic, and the last lobe the largest. The middle incisors are relatively larger in the deciduous than in the permanent series, as compared with the outer ones and the canine in the ordinary Ruminants. The Giraffe deviates furthest from the typical proportions of these teeth in the superior expanse of the bilobed crown of the permanent canine, but it is interesting to find that the deciduous canine, though its crown is also bilobed, is relatively smaller in proportion to the incisors, and thus shows a less amount of deviation from the common type. The third molar is the last inferior true molar. This tooth in the great extinct Sivatherium retained more of the shape of its deciduous analogue, the last milk-molar, than is usually seen in existing species of *Ruminantia*.

The characteristic complexity of the molar teeth of a Ruminant is seen in most of the deciduous series, but in the permanent series only in the three posterior teeth of both upper and lower jaws, which are the true molars; the three first, or premolars, having more simple crowns than those which they displace. The complexity in question is the result of peculiar plications of the formative capsule, some of which are longitudinal, or project inwards from the sides of the capsule, and form peninsular folds of enamel upon the grinding surface of the tooth, whilst others depend vertically from the summit of the matrix into the body of the tooth, and form islands of enamel when the crown begins to be worn. Of the longitudinal folds, two in the upper true molars are external, broad, but shallow, and often sinuous, and one is internal, narrow, and deep, extending quite across the summit of the crown of the tooth, and decreasing in depth towards the base of the crown. The corresponding fold of enamel in the completed tooth, accordingly, extends more or less across the crown, from within outwards, as the tooth is less or more worn. The whole circumference of this complex molar is also invested by a coat of enamel and a thinner layer of cement. In some Ruminants, *e. g.*, Ox, Deer, and Giraffe, a small vertical column (fig. 120, *m*) is developed at the internal interspace of the two lobes of one or more of the upper true molars, varying in height, and rarely reaching the summit of the new-formed crown. Different genera of Ruminants also differ in the depth and sinuosity of the two outer longitudinal folds, and in the depth and complexity of the two vertical folds, which likewise are united in some species by a longer common base than in others, producing thereby a continuity of the enamel, and complete antero-posterior bisection of the grinding surface during a longer period of attrition. The upper molars also differ in their breadth, or antero-posterior diameter, as compared with their thickness or transverse diameter; but as the summit of the crown is always relatively broader in proportion to its thickness, care must be taken to compare teeth of the different species that have been worn to the same extent, or to allow for the difference.

Teeth of Mammals.

In the Ox the outer contour of each lobe of the upper molars is more sinuous than in the Antelope or Sheep, the middle convexity being more prominent and the lateral depressions deeper. The crescentic islands are not so wide as in the larger Antelopes, and the secondary terminal indentations are less marked at the forepart of the island. The small internal accessory column (*e*) forms part of the periphery of the grinding surface at the inner interspace of the lobes, when the crown has been worn down about half an inch, from which part it decreases in size to the beginning of the fangs.

In the Deer (*Cervus*), the inner crescentic subdivision of each lobe is thicker transversely than in the *Bovidæ*. In the great extinct Irish Deer (*Megaceros*, fig. 120), which has molar teeth as large as those of the Aurochs, the crescentic islands are simple, narrow, and more curved or bowed than in the Ox, and in consequence of the later division of the vertical fold of the capsule, the cemental cavity of each is continued into the other until a later period of the attrition of the crown, as shewn in the upper molar (fig. 120). In the Elk (subgenus *Alces*), the central crescents are continuous for a still longer period, and the median longitudinal fold, which divides the crown transversely, retaining its full breadth for a greater extent. The crown of the molar is divided, during a longer period of attrition, by a crucial incision. The molars of the Camel present the most simple condition of the Ruminant type of these teeth; the transverse fold dividing the crown being short, the dentine of the two lobes soon forms a continuous tract. The common base of the crescentic vertical folds of the capsule being likewise short, the enamel islands are soon separated from each other. They include a shallow or narrow crescentic cavity, with a simple but slightly sinuous contour. The two outer shallow longitudinal depressions of the crown have no middle rising; and there is no columnar process at the interspace of the two inner convexities. Bojanus has well illustrated these characteristics of the upper molars of the Camel in his memoir on the *Merycotherium*,[1] a large extinct Cameloid genus of *Ruminantia*, founded on remains discovered in the drift of Siberia; and he has extended the comparison to the Sheep, the Elk, and the Ox.

Cuvier compares the lower molars of the Ruminants to the upper ones reversed. In the lower true molars the single median longitudinal fold is external, and divides the convex outer sides of the two lobes. The base of the fold extends, in some species, across the molar for some distance before it contracts in breadth, retreating towards the outer side, and the two lobes of the crown accordingly continue to be completely divided for a longer period, as in the Elk and Giraffe. The inner surface of the molar is gently sinuous, the concavities being rarely so deep as those of the outer surface of the upper molars. The lower molars are always thinner, in proportion to their breadth, than those above, and the crescentic islands are narrower and less bowed. The differences which the lower molars present in different genera of Ruminants are analogous to those in the upper molars, but are less marked. The accessory small column, when present, as in *Bos*, *Urus*, *Megaceros*, and *Alces*, is situated at the outer interspace of the convex lobes, and nearer the base in the *Cervidæ* than in the *Bovidæ*. It is not developed in the Antelopes, Sheep, or Camel, and is wanting in most of the smaller species of Deer. The last true molar of the lower jaw is characterized in all Ruminants by the addition of a third posterior lobe. This is very small and simple in the Camel and the Gnu, is relatively larger in the *Bovidæ* and *Cervidæ*, and presents, in the *Megaceros* and *Sivatherium*, a deeper central enamel island or fold, which also characterizes the smaller third lobe in the Giraffe. The lower molars of the genus *Auchenia* are peculiarly distinguished by the vertical ridge at the forepart of the anterior lobe, which does not exist in the Camels of the Old World.

In all Ruminants, the outer contour of the entire molar series is slightly zigzag, the anterior and outer angle of one tooth projecting beyond the posterior and outer angle of the next in advance. The premolars are smaller and more simple than the molars, with which they form a continuous series in the true Ruminants. In the upper jaw they are not divided into two lobes by an internal cleft, but resemble a single lobe of the true molars, of greater breadth than thickness, with a single central crescentic island, and usually with an internal nasal ridge.

The central crescents have a more complex contour in *Megaceros* than in *Bos*, and the first premolar, which is always the smallest, is relatively larger in the Deer than in the hollow-horned Ruminants. In the small Musk-deer, the crescentic enamel-island is reduced to a small internal notch or fold, and the outer border of the crown is trenchant and pointed. In the lower jaw the premolars decrease in size from the third to the first, which has usually a compressed conical crown, with a sinuous inner surface. The second and third premolars have two deeper notches on the inner side, and a small second hinder lobe seems to be slightly marked off by a vertical depression on the outer side of the crown. All the three lower premolars have compressed, sub-trenchant, and pointed crowns in the small Musk-deer (*Tragulus*). The true Musk (*Moschus*) more resembles the ordinary Deer in its premolars. The aberrant *Camelidæ* deviate most from ruminant type in the position, shape, and number of the premolars. Teeth of Mammals.

The extinct *Chœropotamus*, *Anthracotherium*, *Hyopotamus*, and *Hippohyus*, had the typical dental formula, and this is preserved in the existing representative of the same section of non-ruminant Artiodactyles, the Hog. The permanent dental formula of the genus *Sus* is illustrated in fig. 20.

Suidæ, Hog-tribe.

The upper incisors (fig. 20, *i*) decrease in size from the first to the third; the first has a short, strong, obtusely-pointed crown, obliquely levelled from the outside of the base to its apex, which inclines towards and touches that in the other premaxillary by its produced inner part; the crown, before it is worn, presents a semilunar depression on its inner side, the concavity of which, directed towards the base, receives a tubercular prominence, it is implanted by a short, thick, curved fang; this incisor is relatively larger in the *Sus larvatus* than in the *Sus scrofa;* the basal line of the enamel is extremely irregular; that substance extends more than an inch upon the outer side of the tooth, but only two or three lines on the inner side, where an angular piece seems to be cut out. The second incisor in the common Hog has a crown as broad as the first, but shorter and thinner; its edge is trenchant and dentated, but is soon worn down; in this state the abraded surface of both incisors shows a dark mark in the centre. The third is a very small tooth, a little removed from the second. The lower incisors are long, sub-compressed, nearly straight; the second is rather larger than the first; the third is the smallest, as in the upper jaw.

The upper canines, in the Wild Boar (fig. 20, *c*) curve forwards, outwards, and upwards; their sockets inclining in the same direction, and being strengthened above by a ridge of bone, which is extraordinarily developed in the Masked Boar of Africa. The enamel covering the convex inferior side of this tusk is longitudinally ribbed, but is not limited to that part; a narrow strip of the same hard substance is laid upon the anterior part, and another upon the posterior concave angle forming the point of the tusk, which is worn obliquely upwards from before, and backwards from that point. In the Sow the canines are much smaller than in the Boar. Castration arrests the development of the tusks in the male.

The teeth of the molar series progressively increase in size from the first to the last. The first premolar (fig. 20, *p* 1) has a simple, compressed, conical crown, thickest behind, and has two fangs; it is further removed from the second in the *Sus larvatus* than in the *Sus scrofa*. The second premolar (fig. 20, *p* 2) has a broader crown with a hind-lobe, having a depression on its inner surface, and each fang begins to be subdivided. The third premolar (fig. 20, *p* 13) has a similar but broader crown implanted by four fangs. The fourth premolar (fig. 20, *p* 4) has two principal tubercles and some irregular vertical pits on the inner half of the crown. The first true molar (*m* 1), when the permanent dentition is completed, exhibits the effects of its early development in a more marked degree than in most other Mammalia, and in the Wild Boar has its tubercles worn down, and a smooth field of dentine exposed by the time the last molar has come into place; it originally bears four primary cones, with smaller subdivisions formed by the wrinkled enamel, and an anterior and posterior ridge. The four cones produced by the crucial impression, of which the transverse part is the deepest, are repeated on the second true molar (fig. 20, *m* 2) with more complex shallow divisions, and a larger tuberculate posterior ridge. The greater extent of the last molar (fig. 20, *m* 3) is chiefly produced by the development of the back ridge into a cluster of tubercles; the four primary cones being distinguishable on the anterior main body of the tooth. The crowns of the lower molars are very similar to those above but are rather narrower, and the outer and inner basal tubercles are much smaller, or are wanting; the grinding surface of the last is shown in fig. 122.

The first or deciduous dentition of the Hog consists of—

$$i\,\tfrac{3.3}{3.3};\ c\,\tfrac{1.1}{1.1};\ m\,\tfrac{3.3}{3.3} = 28, \text{ (fig. 17).}$$

The first milk-incisor above is large, oblique, trenchant, and with a depression on the inner surface of the crown; the second and third are pointed, the latter being as long as the milk-canine. The first and second incisors, below, are trenchant and oblique, and have the indentations and ridge slightly marked on the upper or inner side of the long and narrow crown; the third is pointed, and like a canine. The outer third milk-incisor in both jaws is more advanced in growth than the rest at birth. The canines are feeble, and have their normal direction in both jaws, the upper ones ascending according to the general type, which is not departed from until at a later period of life.

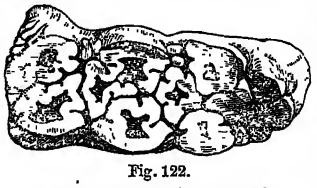

Fig. 122.
Last Lower Molar, Hog. Nat. size.

[1] *Nova Acta Nat. Curios.* 4to, 1824, tom. xii. pt. i. p. 265, tab. xxi.

Teeth of Mammals.

The first deciduous molar is not succeeded by a premolar, but holds the place of such some time after the other deciduous molars are shed and succeeded by the premolars (*p* 2, 3, and 4). The last true molar (fig. 122) is remarkable for its large proportional size and complexity of grinding surface. By the time it is acquired and in use, the first true molar (*m* 1) is worn flat.

The Hog is the only existing hoofed genus that manifests, as regards number, the typical dentition displayed by the *Dichodon* in common with many other Eocene ungulate and unguiculate Mammalia. The deviation in the Hog from this type is slight, being confined to the non-development of *p* 1, and the early reduction of the numerical formula by the loss of the small tooth (*d* 1, fig. 17 at the beginning of the molar series.

That the *Dichodon* belongs to the Artiodactyle series is inferred, notwithstanding the want of any direct evidence of the structure of its limbs, from the more simple form and structure of *p* 1, *p* 2, and *p* 3, as compared with the true molars, and from the symmetrical ruminating pattern of the grinding surface of the crown of the true molars.

From the true Ruminants the *Dichodon* differs in the development of the upper incisors and of *p* 1 in both jaws, which teeth are wanting in all the known existing species.

Such feeble traces of embryotic rudiments of these teeth as have been observed by Professor Goodsir and others, in the Cow and Sheep, and the more conspicuous germs of upper incisors, of which one pair is functionally developed, in the *Camelidæ*, are phenomena that derive increased significance and interest from the fact of the functional development of the same teeth in Artiodactyle Ungulates of the Eocene period.

In the configuration of the true molars the *Dichodon* would seem to be more nearly allied to the Ruminant section of the *Artiodactyla;* in the number and kinds of its teeth it more resembles the Hog-tribe amongst the non-Ruminant section. The known facts of the deciduous dentition of the *Dichodon* supply an additional test of its affinities, owing to the marked differences, in the times and order of succession of the permanent teeth, between the Hog-tribe and the Ruminants, at least in the Ox and Sheep.

In these the last true molar cuts the gum before any of the premolars appear, and the canine teeth ("corner-nippers" of the veterinarians) are the last of the permanent teeth to come into place, their appearance marking the completion of the third year in the Sheep, and a somewhat later period in the Ox. In the Hog the canines appear before the premolars, and these are in place and use before the last molar is on a level with the rest of the grinders.

In the *Dichodon cuspidatus* the second true molar, in the upper jaw, is in place before any of the deciduous series of teeth have been shed; and it is coming into place, with the crown complete, before the pulps of the premolars have even begun to be calcified. The lower jaw of the sheep at from nine to twelve months would afford the nearest parallel amongst existing Artiodactyles to that of the immature *Dichodon* figured in pl. 4. fig. 2, vol. iv. of the *Quarterly Journal of the Geological Society*. But by the time the second true molar in the Sheep is as far advanced in development as in the *Dichodon* (fig. 2, *loc. cit.*, *p.* 2, upper jaw) the first permanent incisor is in place, and the germs of the premolars in the cavities of reserve have calcified crowns.

The subjoined table indicates the several teeth by the symbols explained in the Section on the Homologies of the Teeth.[1]

The necessity of exactness in the records of the age of the valuable breeds of domesticated cattle, exhibited in competition at agricultural meetings, has led to a greater accuracy in the statements of the periods of development of the different teeth in the Ox, Sheep, and Hog; and the results of the writer's observations, with those recorded by Bojanus, the learned veterinary professor at Wilna, and by Mr Simonds, the professor of cattle pathology in the Royal Veterinary College of London,[2] are averaged in the following

Table of the Times of Appearance of the Permanent Teeth in the Ox, Sheep, and Hog.

Teeth of Mammals.

Symbols.	Ox. Early. Year.	Ox. Early. Month.	Ox. Late. Year.	Ox. Late. Month.	Sheep. Early. Year.	Sheep. Early. Month.	Sheep. Late. Year.	Sheep. Late. Month.	Hog. Year.	Hog. Month.
i 1	1	9	2	3	1	0	1	4 to 8	1	0
i 2	2	3	2	9	1	6	2	0 to 4	1	6
i 3	2	9	3	3	2	3	2	9 to 12	0	9
c	3	3	3	9	3	0	3	6	0	9
m 1	0	4	0	6	0	3	0	6	0	6
m 2	1	3	1	8	0	9	1	0	0	10
m 3	2	0	2	3	1	6	2	0	1	6
d or *p* 1	0	0	0	0	0	0	0	0	0	6
p 2	2	6	2	8	2	0	2	6	1	0
p 3	2	6	2	8	2	0	2	6	1	0
p 4	2	8	3	0	2	3	2	6	1	3

Phacochœrus.

The dentition of the Wart-hogs is reduced by the suppression of certain incisors, and of the first two premolars—the tooth-forming energy being, as it were, transferred to the last true molar, which is even more remarkable than in the common hog for its size and complexity in both jaws. Fig. 123 shows the condition of the upper

Fig. 123.

Molar Series of adult Wart-hog (*Phacochœrus*). Nat. size.

molar series in a *Phacochœrus Æliani*, soon after the acquisition of *m* 3. The first true molar (*m* 1), in consequence of its being in place much earlier than the rest of the permanent series, as shown in fig. 124, is now almost worn out. The premolars (*p* 4 and *p* 3) continue

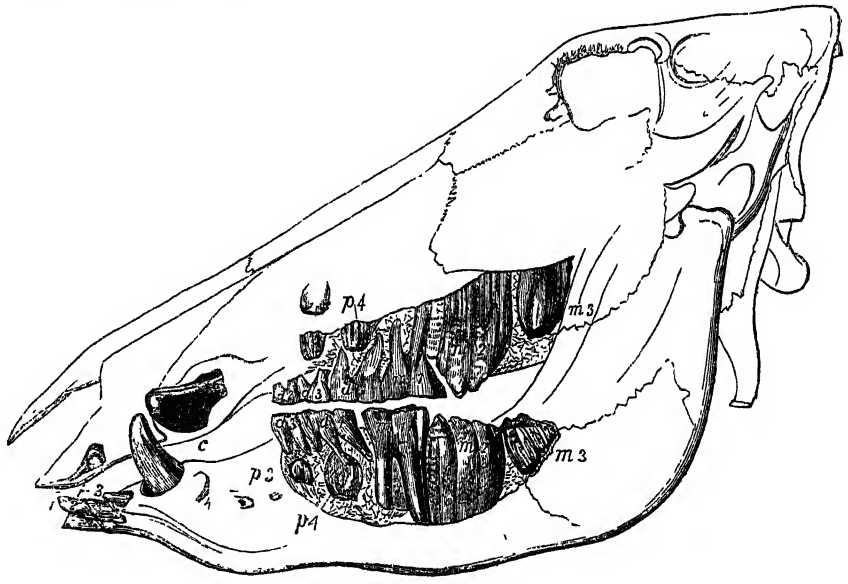

Fig. 124.

Dentition of a Young Wart-hog, *Phacochœrus*.

in use after *m* 1 is shed; and by the modifying growth of the jaw and the pressure on the grinders, they are brought into contact with *m* 2. The writer has seen instances in which *p* 4 has remained after *m* 2 has been shed, and when the molar series has been reduced to the teeth marked *p* 4 and *m* 3. This tooth (fig. 123, *m* 3)—the last true molar—is the most characteristic tooth of the *Phacochœrus*, and perhaps the most peculiar and complex tooth in the whole class of *Mammalia*. The surface of the crown presents three series of enamel islands, in the direction of the long axis of the grinding surface; the middle row, of eight or nine islands, is elliptic and simple; those of the other rows are in equal number, but are sometimes subdivided into smaller islands. These islands or lobes are the abraded ends of long and slender columns of dentine, encased by thick enamel, and the whole blended into a thick coherent crown by abundant cement,

[1] See also *Philosophical Transactions*, 1850, p. 481.

[2] *The Age of the Ox, Sheep, and Pig*, 8vo, 1854.

Teeth of Mammals.

which fills up all the interspaces, and forms a thick exterior investment of the entire complex tooth.

The milk-molars are $\frac{3}{3}.\frac{3}{3}$ in number; but only the two last are succeeded by premolars (fig. 124, *p* 3 and *p* 4), although sometimes a small anterior milk-molar (*d* 2) is developed in the lower, as in the upper jaw. This interesting modification, as to order and number, in the change of the dentition, has thrown important light on the more anomalous dentition of the Elephant.

Hippopotamus.

The tendency to excessive and, as it may be termed, monstrous development which characterises the canine teeth in the typical *Suidæ*, affects both these and the incisors in the present remarkable genus, of which the *Hippopotamus* of the great rivers of Africa is now the sole existing representative.

The two median inferior incisive tusks are cylindrical, of great size and length, obliquely abraded at the upper and outer part of their extremity; the basal portion which is lodged in the deep alveolus is longitudinally grooved; the two outer incisors are likewise cylindrical and straight, are much smaller, and are worn towards the inner side of their point. The upper canines curve downwards and outwards, their exposed part is very short, and is worn obliquely at the forepart from above downwards and backwards; they are three-sided, with a wide and deep longitudinal groove behind. The lower canines (fig. 126) are extremely massive and large, curved in the arc of a circle, subtrihedral, the angle rounded off between the two anterior sides, which are convex and thickly enamelled, the posterior side of the crown being almost wholly occupied by the oblique abraded surface opposed to that on the upper canine. The implanted base of each of these incisive and canine teeth is simple, and excavated for a large persistent matrix, contributing to their perennial growth by constantly reproducing the dental matter to replace the abraded extremities. The direction of the abraded surface is in part provided for by the partial disposition of the enamel. The molar series consists of—

$$p\frac{4.4}{4.4};\ m\frac{3\,3}{3\,3} = 28.$$

The first premolar has a simple subcompressed conical crown, and a single root; it rises early, and at some distance in advance of the second premolar, and is soon shed; the other premolars form a continuous series with the true molars in the existing species, but in the extinct *Hippopotamus major*, whose remains are found in the superficial deposits of this island and on the Continent, the second premolar is in advance of the third by an interval equal to its own breadth. This and the fourth premolar retain the simple conical form, but with increased size, and are impressed by one or two longitudinal grooves on the outer surface, which, when the crown is much worn, give a lobate character to the grinding surface. The true molars are primarily divided into two lobes or cones by a wide transverse valley, and each lobe is subdivided by a narrow antero-posterior cleft into two half cones, with their flat sides next each other; the convex side of each half cone is indented by two angular vertical notches, bounding a strong intermediate prominence. When their summits begin to be abraded, each lobe or pair of demicones presents a double trefoil of enamel on the grinding surface, as shown in fig. 125; when attrition has proceeded to the base of the half cones, then the grinding surfaces of each lobe presents a quadrilobate figure. The crown of the last molar tooth of the lower jaw is lengthened out by a fifth cone, developed behind the two normal pairs of half cones, and smaller in all its dimensions.

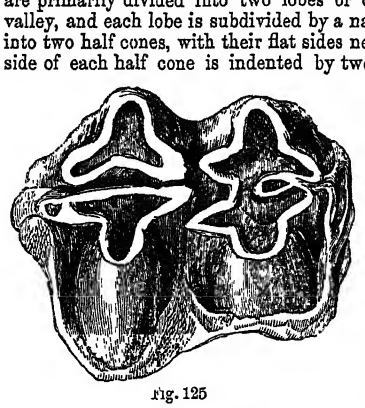

Fig. 125

Molar Tooth, Hippopotamus

The large tusks of the Hippopotamus exhibit the maximum of density in the chief component tissues. The enamel "strikes fire" with steel like flint. The compact dentine has a high commercia value, especially for the fabrication of artificial teeth. It differs from true ivory by showing, in transverse section, the simple concentric instead of the "engine-turned" or curvilinear decussating lines.

In the ordinary-sized tusks the fine-tubed dentine, which forms the concentric-lined ivory, continues with little or no alteration of texture from the periphery to the pulp-cavity; but in very large and old tusks the apex of that cavity contains osteo-dentine, and that tissue is abundantly developed when the normal function of the dentinal pulp is disturbed by injury or disease. A very remarkable example of the inferior tusk of the Hippopotamus is figured in cut 126, exemplifying the subserviency of the osteo-dentine in the reparation of a complete fracture of a tooth.

The injury is indicated externally by a sudden transverse constriction of the tusk (fig. 126), with an interruption in the enamel at that part, and irregular deposits of dentine both there and at the adjoining concavity of the tusk. A longitudinal section of the tusk showed the pulp-cavity obliterated at the fractured part, and for some distance below it, towards the base of the tusk, by a mass of osteo-dentine, deposited principally in the form of nodules closely impacted together, their convex sides projecting into the re-established pulp-cavity next the base, the general disposition of the osteo-dentine being very like that in the centre of the tooth of the Cachalot. The remains of the pulp-cavity in the protruded part, or crown of the tusk, were unusually conspicuous, in the form of a narrow canal near the concave side of the tusk, and opening like a fistula upon that surface just beyond the fracture. Another irregular slender canal extended transversely through part of the uniting substance, and opened upon the concave side of the tusk just below the preceding. From these appearances it may be concluded that the tusk, either by the action of a shot, or other violence, had been snapped across its implanted and hollow base, with probably also fracture and injury to the prominent socket; but that the broken portions being held together by their adhesion to the surrounding parts, inflammation of the pulp and capsule had ensued, ending in an altered mode of action in the calcifying processes, which produced the more vascular substance, which has exemplified its resemblance to true bone by effecting the union of the fracture.

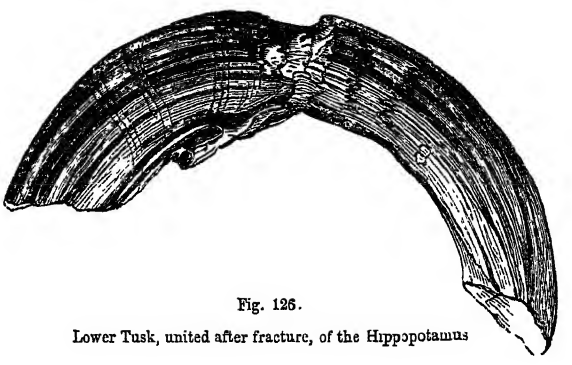

Fig. 126.

Lower Tusk, united after fracture, of the Hippopotamus

Succession.

The true natural affinities of the Hippopotamus are clearly manifested by the character of its deciduous dentition; and if this be compared with the dentition at a like immature period in other *Ungulata*, *e. g.*, with that of the Horse tribe, it will be seen, by its closer correspondence with that of Artiodactyles, and more especially the Phacochere, that the Hippopotamus is essentially a gigantic Hog.

The formula of the teeth, which are shed and replaced, is—

$$i\frac{2.2}{2.2};\ c\frac{1.1}{1.1};\ m\frac{3\,3}{3.3} = 24.$$

If the small and simple tooth, which is developed anterior to the deciduous molars, and which has no successor, be regarded, from its early loss in the existing Hippopotamus, as the first of the deciduous series, we must then reckon with Cuvier four milk-molars on each side of both jaws.

The incisors in both jaws are simply conical and subequal, with an entire cap of enamel on the crown. The deciduous canines scarcely surpass them in size in the upper jaw, and not at all in the lower. Projecting forwards, here, from the angles of the broad and straight symphysis, they appear like an additional pair of incisors; and we have seen that the character of equality of development was retained by the ancient form of Hippopotamus with the more typical number of incisors, $\frac{2}{2}.\frac{3}{3}$, which formerly inhabited India.

The first true deciduous molar has a conical crown and two fangs in both jaws. That above has also a conical crown with one strong posterior and two anterior ridges. The second deciduous molar has a large trilobate crown, the first lobe small, with an anterior basal ridge; the second large, conical, with three longitudinal indentations; the third lobe still larger, and cleft into two half-cones by an antero-posterior fissure assuming the normal pattern of the true molars. The third deciduous molar above more closely resembles the ordinary upper true molar; but its second pair of demi-cones are relatively larger. In the lower jaw the last deciduous molar has a more complex crown than that of any other teeth of the permanent or deciduous dentition.[1] It has three pairs of demi-cones, progressively increasing in size, from before backwards, with an anterior and posterior basal ridge and tubercles. Like the last trilobate deciduous lower molar of the Hog, it increases in thickness posteriorly, instead of diminishing here, like the last true molar of the lower jaw of the adult Hippopotamus.

[1] This tooth is described as the first of four true molars by M. F. Cuvier, *Dents de Mammifères*, p. 207; but its true nature was recognised by Baron Cuvier. See *Ossemens Fossiles*, 4to, i. p. 289.

Teeth of Mammals.

Equidæ.

Perisso-dactyla.

The Horse yields the first example of the dentition of the hoofed Quadrupeds with toes in uneven number, because it offers in this part of its organization some transitional features between those of the dental characters of the typical members of the artiodactyle and of those of the Perisso-dactyle *Ungulata*.

All the kinds of teeth are retained, in nearly normal numbers, in both jaws, and with almost as little unequal or excessive development as in the Anoplothere; but the prolongation of the slender

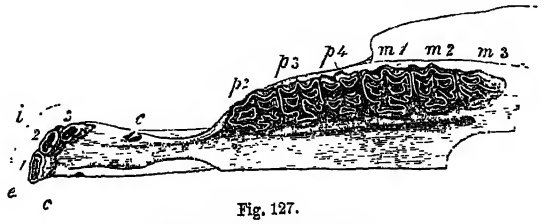

Fig. 127.

Dentition of Upper Jaw, Horse.

jaws carries the canines (figs. 127, 128, *c*) and incisors (ib. *i*) to

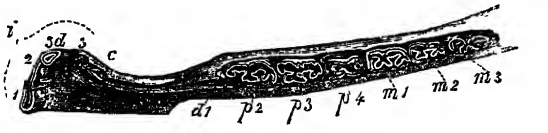

Fig. 128.

Dentition of Lower Jaw, Horse.

some distance from the molars, and creates a long diastema, as in the Ruminants and Tapirs. The first deciduous molar (fig. 129, *d* 1)

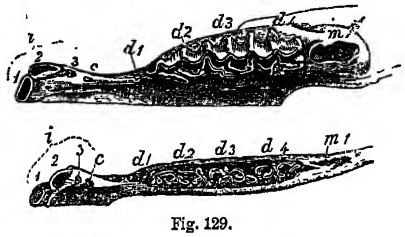

Fig. 129.

Deciduous Dentition, Horse.

is very minute, and is not succeeded, as in the Anoplothere, by a permanent premolar; yet, remaining longer in place than the larger deciduous molars behind, it represents the first premolar, and completes the typical number of that division of the grinding series. If the dental formula of the genus *Equus* be restricted to the functionally developed permanent teeth, it will be—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3};\ = 40.$$

The outer side of the upper molar of the Horse (*Equus Caballus*, fig. 130) is impressed, as in the Palæothere (fig. 117), by two wide longitudinal channels (fig. 130, *f*, *f*). The depression (*i*) is separated from the oblique valley (*e*); the depression (*g*) forms a crescentic island like *i*, when the crown begins to be worn away. There is a smaller depression (*h*) which indents the hinder side of the crown. An accessory lobe, apparently answering to that marked *m* in *Anoplotherium* (fig. 116), but more probably answering to the inner end of the lobe (*d*) in the Rhinoceros (fig. 132), is marked off by the anterior indentation (*k*), and adds to the complexity of the crown, which, in the general aspect of the grinding surface, approaches in character to that of the Ruminants (fig. 120). In the lower jaw, the correspondence of type with that of the Rhinoceros is more obvious. The teeth here, as is usual in other quadrupeds, are narrower transversely than in the upper jaw; they are divided externally into two convex lobes (pl. 128, *m* 1 and 2) by a median longitudinal fissure, and on the inner side they present three principal unequal convex ridges, and an anterior and posterior narrower ridge; but the crown of the molar is penetrated from the inner side by deeper and more complex folds than in the Rhinoceros or Palæothere. The anterior one, between the narrow ridge and the first principal internal column, expands into a sub-crescentic fold; the second is a short, simple fold, and terminates opposite that which penetrates the tooth from the outer side; the third inner fold expands in the posterior lobe of the tooth, like the first. Two short folds partially detach a small accessory lobe at the posterior part of the crown.

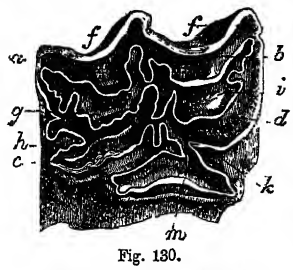

Fig. 130.

Upper Molar, Horse. Nat. size.

Teeth of Mammals.

The incisors (figs. 127, 128, *i*) are arranged close together in the arc of a circle at the extremity of both jaws. They are slightly curved, with long simple subtrihedral fangs tapering to their extremity (fig. 131). The crowns are broad, thick, and short. The contour of the biting surface, before it is much worn, approaches an ellipse. These teeth, if found detached, recent or fossil, are distinguishable from those of the Ruminants by their greater curvature, and from those of all other animals by the fold of enamel (fig. 131, *c'*) which penetrates the body of the crown from its broad flat summit, like the inverted finger of a glove. When the tooth begins to be worn, the fold forms an island of enamel inclosed in a cavity, partly filled by cement and partly by the discoloured substances of the food; this is called by horse-dealers the "mark." In aged horses the incisors are worn down below the extent of the fold, and the mark disappears. The cavity is usually obliterated in the first, or mid-incisors at the sixth year, in the second incisors at the seventh year, and in the third or outer incisors, at the eighth year, in the lower jaw. It remains longer in those of the upper jaw, and in both the place of the mark continues for some years to be indicated by the dark-coloured cement.

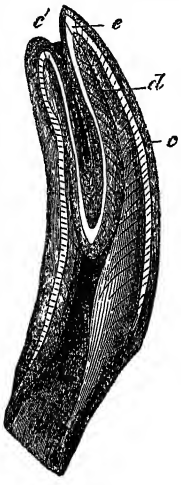

Fig. 131.

Section of Incisor. Horse.

The canines (figs. 127 and 128, *c*) are small in the stallion, less in the gelding, and rudimental in the mare. The unworn crown is remarkable for the folding in of the anterior and posterior margins of enamel, which here includes an extremely thin layer of dentine. The upper canine (fig. 127, *c*) is situated in the middle of the long interspace between the incisors and molars. The lower canine (fig. 128, *c*) is close to the outer incisor, as in the Ruminants, but is better distinguished by its cuspidate form. The antetype, or representative of the first premolar (fig. 129, *d* 1), is a very small and simple rudiment, and is soon shed. The three normal premolars (figs. 127, 128, *p* 2, 3, and 4) are as large and complex as the true molars (figs. 127, 128, *m* 1, 2, 3). The anterior one (*p* 2) is usually the largest of the series in the upper jaw, the anterior lobe extending forwards into an obtuse angle.

The most obvious character by which the horse's molars may be distinguished from the complex teeth of other *Herbivora* corresponding with them in size, is the great length of the tooth before it divides into fangs. This division, indeed, does not begin to take place until much of the crown has been worn away; and thus, except in old horses, a considerable portion of the whole of the molar is implanted in the socket by an undivided base. This is slightly curved in the upper molars.

The following is the average course of development and succession of the teeth in the *Equus Caballus*:—The summits of the first functional deciduous molar (fig. 129, *d* 2, "first grinder" of veterinary authors) are usually apparent at birth; the succeeding grinder (*d* 3) sometimes rises a day or two later, sometimes together with the first. Their appearance is speedily followed by that of the first deciduous incisor (fig. 129, *i* 1, "centre nipper" of veterinarians) which usually cuts the gum between the third and sixth days. The second deciduous incisor (fig. 129, *i* 2) appears between the twentieth and fortieth days, and about this time the rudimental grinder (*d* 1) comes into place, and the last deciduous molar (*d* 4) begins to cut the gum. About the sixth month the inferior lateral or third incisors (fig. 129, *i* 3), with the deciduous canine (*c*), make their appearance. The minute canine is shed about the time that the contiguous incisor is in place, and is not retained beyond the first year. The upper deciduous canine is shed in the course of the second year. The appearance of the third deciduous incisors or "corner nipper" completes the stage of dentition called the "colt's mouth" by veterinary authors. The first true molar (*m* 1) appears between the eleventh and thirteenth months. The second molar (*m* 1) follows before the twentieth month. The first functional premolar (*p* 2) displaces the deciduous molar (*d* 2) at from two years to two years and a half old. The first permanent incisor (figs. 127 and 128, *i* 1) protrudes from the gum at between two years and a half and three years. At the same period the second, or penultimate premolar (ib. *p* 3), pushes out the penultimate milk-molar (fig. 129, *d* 3), and the penultimate true molar (*m* 2) comes into place. The last premolar (*p* 4) displaces the last deciduous molar at between three years and a half and four years; the appearance above the gum of the last true molar (*m* 3) is usually somewhat earlier. The second incisor (*i* 2) pushes out its deciduous predecessor about the same period. The permanent canine or "tusk" (*c*) next follows; its appearance indicates the age of four years, but it sometimes comes earlier. The third, or outer incisor (fig. 128, *i* 3), pushes out the deciduous incisor (ib. 3 *d*) about the fifth year, but is

Teeth of Mammals.

seldom in full place before the horse is five years and a half old; the last premolar is then usually on a level with the other grinders. Upon the rising of the third permanent incisor, or "corner nipper" of the veterinarians, the "colt" becomes a "horse," and the "filly" a "mare," in the language of the horse-dealers; after the disappearance of the "mark" in the incisors, at the eighth or ninth year, the horse becomes "aged."

Rhinoceros.

The modifications which the upper molars of the rhinoceros present, as compared with those of its antetype, the Palæotherium, will be readily understood by comparing fig. 117 with fig. 132, and are

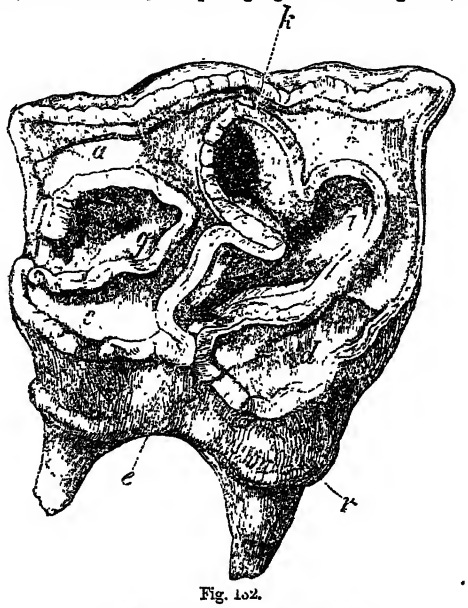

Fig. 102.

Upper Molar, Rhinoceros. Nat. size.

as follows:—The concavities (*f f*) on the outer side of the crown, in fig. 117, are almost levelled, and from one of them a slight convexity projects, in some species of Rhinoceros, giving a gently undulated surface on that side of the crown. The valley (*e*) is more expanded at its termination (*i*), and in some species bifurcates and deepens, so that one branch may form an insulated circle of enamel when the crown is worn. The posterior valley (*g*) is usually deeper and more extended. The ordinary lobes (*a*, *b*, *c*, *d*) are very similar, and produce, by the confluence of *a* with *c*, and of *b* with *d*, the two oblique tracts of dentine which are more decidedly established as transverse ridges in the Lophiodont or Tapiroid group. A basal ridge (*r*) girts more or less completely the inner and the fore and hind parts of the base of the crown.

The formula of the functional molar series is—

$$p\,\tfrac{4.4}{4.4};\ m\,\tfrac{3.3}{3.3} = 28.$$

There are no canines. As to the incisors, the species vary, not only in regard to their form and proportions, but also their existence; and in the varieties of these teeth we may discern the same inverse relation to the development of the horns which is manifested by the canines of the Ruminants. Thus, the two-horned Rhinoceroses of Africa, which are remarkable for the great length of one (*Rh. bicornis*, *Rh. simus*) or both (*Rh. Keitloa*) of the nasal weapons, have no incisors in their adult dentition, neither had that great extinct two-horned species (*Rh. tichorinus*), the prodigious development of whose horns is indicated by the singular modifications of the vomerine, nasal, and pre-maxillary bones, in relation to the firm support of those weapons. The Sumatran bicorn Rhinoceros combines, with comparatively small horns, moderately-developed incisors in both jaws; and the same teeth are present in the nearly allied extinct two-horned Rhinoceros, called, after its discoverer, *Schleiermacheri*. The incisors are developed in both the existing Unicorn Rhinoceroses, (*Rh. Indicus* and *Rh Sondaicus*), but they attain their largest dimensions in the singular extinct hornless species, the *Rhinoceros incisivus* of Cuvier, which makes the transition to the extinct genus *Palæotherium*, and forms the type of the aberrant subgenus *Acerotherium* of Dr Kaup.

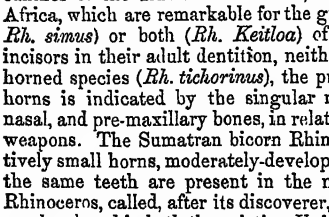

Fig. 133.

Lower Molar, Rhinoceros.

The molar teeth in the lower jaw consist of two subequal oblique crescentic or semicylindrical lobes, which, when slightly worn, present the appearance shewn in the middle of the three figures in cut 133, from a molar of the right ramus of the lower jaw. The figure opposite the right hand shews the outer side, that opposite the left hand the inner side. In each figure, *a d* is the anterior lobe, *b e* the posterior lobe; *c* is the antero-internal border, and *d* the postero-internal border of the anterior lobe; *e* is the postero-internal border of the posterior lobe; *f* is the concavity of the anterior, *g* that of the posterior lobe. The above structure characterises the last two premolars and all the true molars of the lower jaw of the Rhinoceros, the ultimate one not being characterised, as in the *Palæotherium*, by an accessory lobe.

Teeth of Mammals.

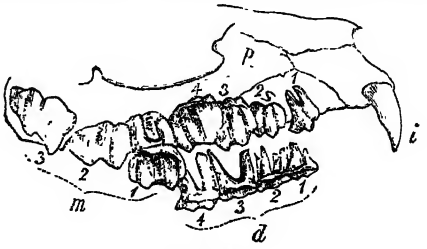

Fig. 134.

Deciduous and Permanent Teeth, Hyrax. Nat. size.

The deciduous molars of the Rhinoceros are, in number as well as in shape, closely similar to those in the diminutive, hornless, hairy, rhinoceros-like quadruped, called *Hyrax*, which bears the same relation to the great Rhinoceros as the small existing Sloth does to the extinct Megatherium. The change of dentition of the *Rhinocerotidæ* is, therefore, here illustrated by the young *Hyrax capensis* (fig. 134).

The law of development, so instructive and constant in the placental *Diphyodonts*, is well illustrated in this species. The four premolars (*p* 1, 2, 3, 4) are exposed above the four deciduous molars (*d* 1, 2, 3, 4), which they push out; the first true molar (*m* 1) is in place; the second (*m* 2) and third (*m* 3) molars are in different states of forwardness. The first premolar differs from the rest only by a graduated inferiority of size, which, in the last premolar (*p* 4), ceases to be a distinction between it and the true molars.

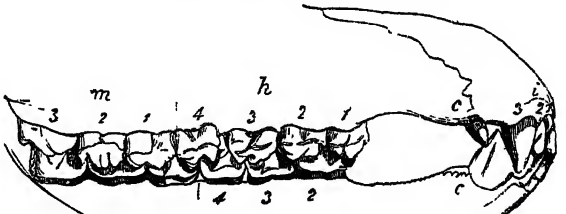

Fig. 135

Dentition of the Tapir.

Tapirus.

The dental formula of the Tapir is—

$$i\,\tfrac{3.3}{3.3};\ c\,\tfrac{1.1}{1.1};\ p\,\tfrac{4.4}{\ };\ m\,\tfrac{3.3}{3.3} = 42 \text{ (fig. 135).}$$

The median incisors above (*i* 1, 2, 3) have a broad trenchant crown, separated by a transverse channel from a large basal ridge; the wedge-shaped crowns of the opposite pair below fit into the channel, and have no basal ridge; the outer incisors above (*i* 3) are very large and like canines; those below are unusually small. The canines (fig. 135, *c*) have crowns much shorter than their roots, and not projecting, like tusks, beyond the lips; they are pointed, with an outer convex, separated by sharp edges from an inner, less convex, surface. The lower canines form part of the same semicircular series with the incisors; the upper ones project close to the intermaxillary suture, separated from the incisors by a short space for the reception of the crown of the lower canine. The first three premolars above (*p* 1, 2, 3) have the outer part of the crown composed of two half cones, the posterior one having a basal ridge; the anterior basal ridge rises into a small cusp in the second premolar, which increases in size in the third and fourth; in this tooth (*p* 4) the transverse depression divides at the base of the anterior and outer demicone, and the posterior division is continued into the interspace of the two demicones; these, therefore, now become in *m* 1 and 2 the outer ends of the two transverse wedge-shaped eminences, giving their summits a curve whose concavity is turned backwards; the last molar (*m* 3) may be known by the shorter and more curved posterior eminence. In the dentition of the lower jaw (fig. 136) the double transverse ridged type of tooth, which has been before described in the Kangaroo,

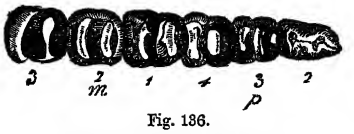

Fig. 136.

Molar Series, Lower Jaw, Tapir.

Teeth of Mammals.

Diprotodon, and Manatee, prevails throughout the molar series, the anterior talon being most produced and compressed in the first tooth (*p* 2).

The most extraordinary of extinct Pachyderms is that which Cuvier regarded as a gigantic Tapir, on account of the character of the molar teeth (see the lower fig. in cut 137); but which subsequent

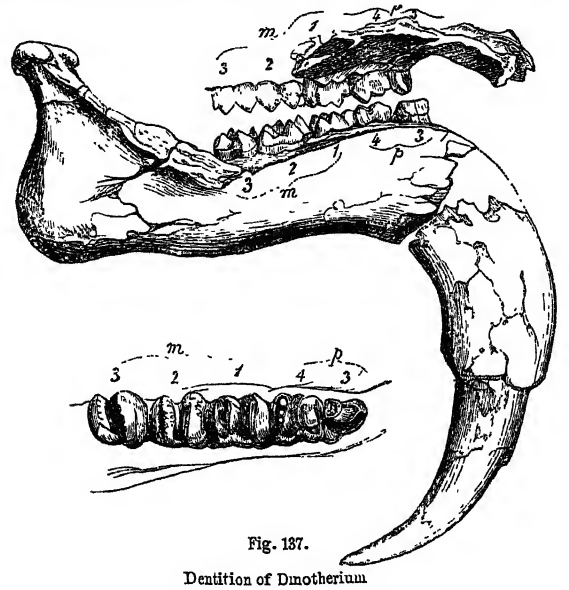

Fig. 137.

Dentition of Dinotherium

discovery of the cranium, and the enormous tusks of the lower jaw (fig. 137), has proved to be a genus connecting the tapiroid with the proboscidian families of Perissodactyla.

The permanent dentition of the genus *Dinotherium* is—

$$i\,\frac{0\,0}{1.1};\ c\,\frac{0.0}{0\,0};\ p\,\frac{2.2}{2.2};\ m\,\frac{3.3}{2.2} = 22.$$

The two deciduous molars *in situ* on each side of the fragment of the upper jaw of the young *Dinotherium*, which Professor Kaup has figured in Tab. 1 of his *Ossemens Fossiles de Darmstadt*, answer to the third and fourth of the typical series. The crown of the anterior milk-molar supports two transverse ridges with an anterior and posterior basal ridge; its contour is almost square; the last milk-molar has a greater antero-posterior extent, and supports three transverse eminences with an anterior and posterior basal ridge, the anterior ridge being developed into a pointed tubercle at its outer end. The two premolars (fig. 137, *p* 3 and 4) conform to the general rule in being more simple than the teeth which they displace and succeed. The first upper premolar (*p* 3) supports a longitudinal ridge on the outer side of the crown, and two mamilloid tubercles, with confluent bases along the inner side of the crown, which is surrounded, except at its outer part, by a basal ridge. The unworn summits of both the ridge and tubercles are divided into smaller tubercles by a series of notches. The crown of the second premolar (*p* 4) supports four tubercles, the outer ridge being deeply cleft, and the two anterior tubercles are united by a continuous ridge, which converts them into a transverse eminence, like those which characterise the true molar teeth. The transverse diameter of the second premolar exceeds the antero-posterior one, the proportions being the reverse of those of the deciduous molar, which it displaces. The first true molar (*m* 1) repeats the structure of the hindmost deciduous molar, its crown having a disproportionate antero-posterior extent, and supporting three transverse eminences, with an anterior, posterior, and internal basal ridge. The Dinothere resumes the Tapiroid character, and differs essentially from the Mastodon, inasmuch as the posterior molars (*m* 2 and 3), instead of having an increased antero-posterior extent and more complex crowns, increase only in thickness, and support two instead of three transverse eminences; they have also an anterior and a posterior basal ridge. In the lower jaw the first premolar (*p* 3) is implanted, like that above, by two fangs; but it has a smaller and simpler crown, which is narrower in proportion to its antero-posterior extent, and is almost entirely occupied by the antero-posterior ridge, only the posterior of the two inner tubercles being developed; thus the crown presents more of a trenchant than of a grinding character; the second premolar (*p* 4) supports two transverse ridges. The third of the permanent series, which is the first true molar (*m* 1), has three transverse ridges, like the one above, but is relatively narrower, the second (*m* 2) and third (*m* 3) true molars have each large square crowns, with two transverse ridges, and an anterior and posterior talon, the latter being more developed than in the corresponding molars of the upper jaw. Teeth of Mammals.

As the three-ridged or first true molar tooth is the first of the permanent series which comes into place, its crown, conformably with the general law, exhibits most abrasion.

The generic peculiarity of the *Dinotherium* is most strongly manifested in its tusks. These tusks (fig. 137) are two in number, implanted in the prolonged and deflected symphysis of the lower jaw, in close contiguity with each other, and having their exserted crown directed downwards and bent backwards, gradually decreasing to the pointed extremity. Each tusk has a slight longitudinal depression on its outer side; the long implanted base is excavated by a wide and deep conical pulp-cavity, like the tusks of the Mastodon and Elephant.

In jaws with molar teeth of equal size, the symphysis and its tusks offer two sizes; the larger ones, which have been found four feet in length, with tusks of two feet, may be attributed to the male Dinothere; the smaller specimens, with tusks of half size, to the female. The ivory of these tusks presents the fine concentric structure of those of the Hippopotamus, not the decussating curvilinear character which characterises the ivory of the Elephant and Mastodon. No corresponding tusks, nor the germs of such, have yet been discovered in the upper jaw of the *Dinotherium*.

No family of Mammalian quadrupeds has suffered more from the destructive operations of time than that which is characterised by the gigantic size of the individuals composing it, and their peculiar endowment of a long and prehensile proboscis. The Elephants of Africa, India, Ceylon, and Sumatra, represent the proboscidian type of the hoofed series of mammals at the present day; but much more numerous species of as huge proboscidians formerly existed, dispersed over a wider geographical range, and in which the Elephantine dentition was reduced by gradational series of modifications almost to the comparative simplicity of that of the Dinothere and Tapir. Proboscidians.

The name *Mastodon* was applied by Cuvier to certain species, which, being at the Tapiroid or Dinotherian extremity of the proboscidian series, manifested modifications of the teeth most meriting to be held generically distinct from those of the existing Elephants. The grinding surface of the molars (fig. 138), instead of being cleft into numerous thin plates, was divided into wedge-shaped transverse ridges, and the summits of these were subdivided into smaller cones, more or less resembling the teats of a cow, whence the generic name.[1] A more important modification appeared to distinguish the extinct genus, in respect of the structure of the molar teeth; the dentine, or Mastodon.

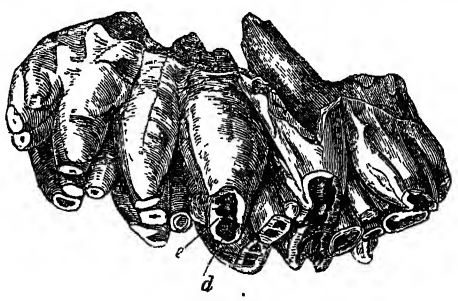

Fig 138.

Upper Molar of Mastodon.

principal substance of the crown of the tooth (fig. 138, *d*) is covered by a thick coat of dense and brittle enamel (*e*); a thin coat of cement is continued from the fangs upon the crown of the tooth, but this substance does not fill up the interspaces of the divisions of the crown, as in the Elephants (fig. 144, *c*). Such at least is the character of the molar teeth of the typical and first-discovered species of Mastodon, which Cuvier has termed *Mastodon giganteus* and *Mastodon angustidens* (fig. 138). Fossil remains of proboscidians have subsequently been found principally in the tertiary deposits of tropical Asia, in which the number and depth of the clefts of the crown of the molar teeth, and the thickness of the intervening cement, are so much increased as to establish transitional characters between the lamello-tuberculate teeth of the Elephants and the mammilated molars of the typical Mastodons, showing that the characters deducible from the molar teeth are rather the distinguishing marks of species than of genera in the present family of mammalian quadrupeds.

The dentition of this family may be expressed by the formula—

$$d\,i\,\frac{1.1}{\ldots};\ i\,\frac{1.1}{1.1};\ c\,\frac{0\,0}{0.0};\ m\,d\,\frac{3.3}{3.3};\ p\,\frac{1.1}{1.1};\ m\,\frac{3.3}{3\,3} = 34;$$

that is to say, in the proboscidians in which the dentition most nearly approached to the typical one, thirty-four teeth were developed,

[1] μαστος, a nipple; οδους, a tooth.

Teeth of Mammals.

as follows:—In the upper jaw two deciduous incisors, followed by two permanent incisors developed as tusks; six deciduous molars, (three on each side, *d* 2, 3, 4, fig 3 9 ; two premolars (one on each side, *p* 3, fig. 139), and six true molars (three on each side, *m* 1, 2, 3, figs. 139 and 140):—in the lower jaw, two incisors as tusks (uncertain whether preceded by deciduous tusks), deciduous molars, premolars, and molars, as in the upper jaw. The Elephantoid animal (*Mastodon longirostris*, Kaup; *Mastodon angustidens*, in part, Cuvier) which exhibited the above instructive dentition of the Proboscidian family, once roamed over the part of the earth now forming England, France, Italy, and Germany. The first steps in our knowledge of its dentition were made by Cuvier, who called it the narrow-toothed Mastodon "Mastodon à dents étroites," or *Mastodon angustidens*. This name was suggested by the less breadth of the grinding surface

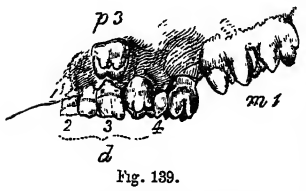

Fig. 139.

Deciduous dentition, young *Mastodon longirostris*.

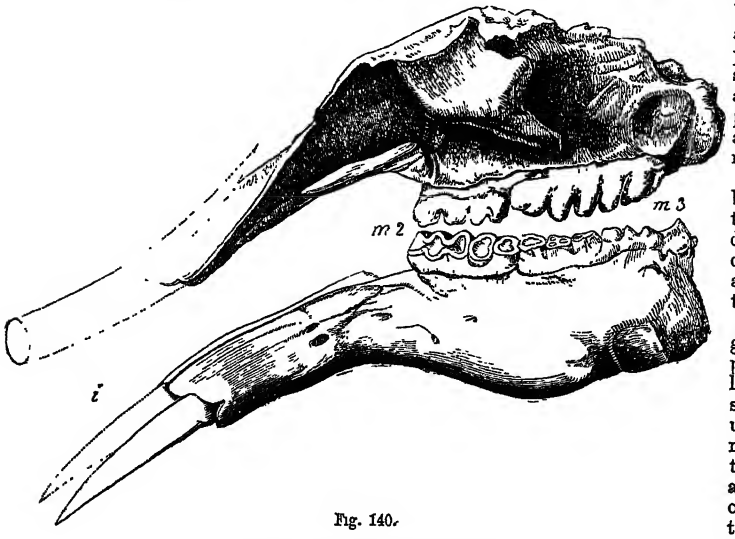

Fig. 140.

Dentition of old *Mastodon longirostris*.

of the teeth as compared with those of a previously described species of Mastodon from North America, called the *Mast. giganteus* or *M. Ohioticus*. Cuvier describes and figures a last molar, upper jaw, from Trévoux, consisting, as in the specimen from Norfolk Crag (fig. 138), and as in that from Eppelsheim (fig. 140, *m* 3), of five transverse ridges, with a front and back talon or subsidiary ridge. The latter is the largest, and subdivided into teat-shaped tubercles, so as almost to merit the name of a sixth division of the tooth. The principal ridges are divided into two chief or primary tubercles, with secondary tubercles in the interspace; the chief tubercles are more or less deeply grooved lengthwise, or cleft at top, so that mastication wore them down to small circles of dentine surrounded by a thick border of enamel, and further attrition reduced these to a trilobed or trefoil form.

The last lower molar of the *Mast. angustidens* from La Rochetta di Tanaro,[1] exhibits the same five principal transverse ridges and the hinder one, as in the corresponding tooth in the Eppelsheim Mastodon (fig. 140, *m* 3), and being the first of the series of narrow mastodontoid teeth to which Cuvier applied the name *angustidens*, it may be regarded as the type of that species. The characteristic premolar of the *Mast. angustidens*, with a quadrate crown of two ridges, each cleft into two tubercles (fig 139, *p* 3), is figured by Cuvier, in Op. cit. pl. i., fig. 3, and again, *in situ*, with the last deciduous molar (*d* 4) in a portion of the upper jaw of the *Mastodon angustidens* from Dax (ib. pl. iii., fig. 2). The nature of this quadrituberculate tooth as a premolar, *i. e.*, as a tooth which displaced and succeeded an earlier or deciduous tooth in the vertical direction, was recognised by Cuvier. "Je crois encore qu'on peut en conclure que la dent antérieure était susceptible de remplacement de haut ou bas, comme dans l'hippopotame: ma raison est, que cette petite dent de Dax n'est pas encore usée et qu'il faut qu'elle soit venue après la grande qui l'est."[2] Dr Kaup has described and figured the same premolar in the upper jaw of a younger individual of the *Mastodon angustidens* (his *longirostris*), in which it is still concealed in its formative cavity above the three-lobed deciduous tooth which it has replaced in Cuvier's specimen. The tooth next behind, which is the homologue of the last milk-molar (*d* 4, fig. 139) of the typical series, consists, in both the Dax and Eppelsheim specimens, of three principal ridges and a posterior bituberculate talon; this accessory portion being more developed in the Eppelsheim specimen. Whether such difference be valid for a specific distinction may be doubted; but that Cuvier assigned the name *angustidens* to a *Mastodon* with narrower molars than the *M. giganteus*, which had a quadri-tuberculate premolar, a penultimate molar of four principal divisions and a talon, and a last molar with five principal divisions and a talon, is certain. To that Mastodon, therefore, which has the same shaped and sized ultimate and penultimate true molars and premolar, the same name is here assigned.

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The antepenultimate molar (fig. 139, *m* 1) consists of four ridges and a talon.

Three molars are developed anterior to this tooth; the first (fig. 3, *d* 2) is the smallest, with a subquadrate crown of two transverse ridges. The second molar (fig. 3, *d* 3), of twice the size of the first, has three ridges. The third molar (*d* 4), with an increase of one third the bulk of the former, has three ridges and a bituberculate talon, which in some specimens might almost be reckoned as a fourth ridge. The two-ridged premolar (*p* 3) above described, takes the place of the second of the above molars, after the first and second are shed. The above definition of the molar series applies to both upper and lower jaws, the cut (fig. 136), and the symbolic letters and numbers, preclude the necessity of verbal description.

From the analogy of the existing elephants, it may be inferred that the long tusks (fig. 137, *i*) supported by the premaxillaries, were preceded by a pair of small deciduous incisors. There is not such ground for concluding their existence in the mandible; but this jaw, at least in the male *Mastodon*, supported two incisive tusks, shorter and straighter than those above.

In the Proboscidian quadrupeds the molar teeth, progressively increasing in size, and most of them in complexity, follow each other from before backwards, at longer intervals than in other quadrupeds, and are never simultaneously in place. Not more than three are in use at any period on one side of either jaw; all the molars, save the penultimate (fig. 140, *m* 2) are shed by the time the crown of the last molar has cut the gum, and the dentition is finally reduced to *m* 3 on each side of both jaws, with commonly the loss of the inferior tusks, as in the old *Mastodon angustidens*, from the tertiary deposits of the Po, described and figured by Sismonda.[3]

The readiest and most intelligible key to the homologies of the above-described dentition, aberrant as regards the Mammalian type, but typical amongst the Proboscidian modifications, is that afforded by the Wart-hog (*Phacochœrus*). In fig. 122 the symbols are attached to the several teeth indicative of their homologies, as undoubtedly determined by comparison with the Hogs that retain the typical dentition.

The Wart-hog, moreover, is the hoofed animal that makes the nearest approach to the Elephant in the complex structure of the molars, in their progressive increase of size and complexity, in the early loss of the anterior molars, and the ultimate reduction of the series to the last large and complex one (*m* 3).

In Phacochœrus (fig. 122) only the last two premolars (*p* 3 and 4) are developed; in *Mastodon* (fig. 136) only the penultimate one (*p* 3); in *Elephas* proper, even this tooth becomes obsolete, and the guide to the deciduous molars is restricted to the homology of the true molars (*m* 1, *m* 2, and *m* 3), with the answerable teeth in *Mastodon* and *Phacochœrus*.[4]

As to the teeth anterior to the molar series, some might be tempted to regard the tusks of the Proboscidian as the homologue of the tusk-like canines of the boar tribe, advanced to the position of the incisors, which are in that view wholly wanting. But the numerous instances in which in *Herbivora*, the canines are obsolete whilst the incisors are retained, and the true incisive nature of the premaxillary tusk-like teeth in the Rodents, show the determination of the premaxillary and symphysial tusks of the Proboscidians, as incisors, to be the sounder conclusion.

Elephas.

The dentition of the genus *Elephas*, the sole existing modification of the once numerous and various Proboscidian family, includes two long tusks, one in each of the premaxillary bones, and large and complex molars in both jaws. Of the latter there is never more than one wholly, or two partially, in place and use on each side at any given time, the series continually being in progress of formation

[1] Cuvier, *Op. cit. Divers Mastodontes*, pl. iv., fig. 1, top view, fig. 2, side view.
[2] *Ossemens Fossiles*, 4to, 1821, tom. i. p. 256.
[3] *Osteografia di un Mastodonte Angustidente*, 4to, Turin, 1851.
[4] *Odontography*, p. 621.

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and destruction, of shedding and replacement; and, in the Elephants, all the grinders succeed one another, like true molars, horizontally, from behind forwards. The *total* number of teeth developed in the Elephant appears to be—

$$di\,\frac{1.1}{0.0};\ i\,\frac{1.1}{0.0};\ dm\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3} = 28.$$

The two large permanent tusks are preceded by two small deciduous ones, and the number of molar teeth which follow one another on each side of both jaws is certainly not less than six, of which the last three answer to the last three in the Mastodon, and to the true molars, *m* 1, 2 and 3, of other diphyodont placental Mammals. The writer has shewn in his *Odontography*, that "the deciduous tusk makes its appearance beyond the gum between the fifth and seventh months. It rarely exceeds two inches in length, and is about a third of an inch in diameter at its thickest, where it protrudes from the socket. The fang is solidified, and contracts to its termination, which is commonly a little bent, and is considerably absorbed by the time the tooth is shed, which takes place between the first and second year." "The socket of the permanent tusk in a new-born Elephant is a round cell about three inches in diameter, situated on the inner and posterior side of the aperture of the temporary socket." The permanent tusks cut the gum when about an inch in length, a month or two usually after the milk-tusks are shed. At this period, according to Mr Corse,[1] the permanent tusks are "black and ragged at the ends; when they become longer, and project beyond the lip, they soon are worn smooth by the motion and friction of the trunk." Their widely-open base is fixed upon a conical pulp, which, with the capsule surrounding the base of the tusk and the socket, continues to increase in size and depth, obliterating all vestiges of that of the deciduous tusk, and finally extending its base close to the nasal aperture. The ivory of the tusk is formed by successive calcification of layers of the pulp, in contact with the inner surface of the pulp-cavity; and, being subject to no habitual attrition from an opposed tooth, but being worn only by the occasional uses to which it is applied, it arrives at an extraordinary length. It follows the curve originally impressed upon it by the form of the socket, and gradually widens from the projecting apex to that part which was formed when the matrix and the socket had reached their full size.

These incisive teeth of the Elephant not only surpass other teeth in size as belonging to a quadruped so enormous, but they are the largest of all teeth in proportion to the size of the body; representing, in a natural state, those monstrous incisors of the Rodents (fig. 92), which are the result of accidental suppression of the wearing force of the opposite teeth.

The tusks of the Elephant, like those of the Mastodon, consist chiefly of that modification of dentine which is called "ivory," and which shows, on transverse fractures or sections, striæ proceeding in the arc of a circle from the centre to the circumference in opposite directions, and forming, by their decussations, curvilinear lozenges. This character is peculiar to the tusks of the Proboscidian Pachyderms, and is characteristic of true ivory. In the Indian Elephant there is a well-marked sexual difference in the growth of the tusks. They are always short and straight in the female, and less deeply implanted than in the male; she thus retaining, as usual, more of the characters of the immature state. In the male they have been known to acquire a length of nine feet, with a basal diameter of eight inches, and to weigh one hundred and fifty pounds; but these dimensions are rare in the Asiatic species.

Mr Corse, speaking of the variety of Indian Elephant, called "Dauntelah" from its large tusks, which project almost horizontally with a slight curve upwards and outwards, says: "The largest I have known in Bengal did not exceed seventy-two pounds avoirdupois; at Tiperah they seldom exceed fifty pounds." There are varieties of the Dauntelah, in which the large tusks of the male are nearly or quite straight; and in a more marked breed called "Mooknah" the tusks are much smaller, are straight, and point directly downwards. These ascertained varieties in an existing species ought to weigh with the observers of analogous varieties in the teeth of fossil Proboscidians, before they pronounce definitely on their value as characters of distinct species. More anomalous varieties occasionally present themselves in the African Elephant, as when one tusk is horizontal, the other vertical, or when, from some distortion of the alveolus, a spiral direction is impressed upon the growth of the tusk, as in that specimen figured by Grew in the "Rarities of Gresham College," tab. 4, and which is now in the Museum of the Royal College of Surgeons, London,[2] The tusk of the Elephant is slightly movable in its socket, and readily receives a new direction of growth from habitual pressure; this often causes distorted tusks in captive Elephants; and Cuvier relates the mode in which advantage was taken of the same impressibility in order to rectify the growth of such tusks in an Elephant kept at the Garden of Plants in Paris.

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The tusks of the extinct *Elephas primigenius*, or mammoth, have a bolder and more extensive curvature than those of the *Elephas indicus;* some have been found which describe a circle, but the curve being oblique, they thus clear the head, and point outwards, downwards, and backwards. The numerous fossil tusks of the Mammoth which have been discovered and recorded, may be ranged under two averages of size—the larger ones at nine feet and a half, the smaller at five feet and a half in length. The writer has elsewhere[3] assigned reasons for the probability of the latter belonging to the female Mammoth, which must accordingly have differed from the existing Elephant of India, and have more resembled that of Africa in the development of her tusks, yet manifesting an intermediate character by their smaller size. Of the tusks which are referable to the male Mammoth, one from the newer tertiary deposits in Essex measured nine feet ten inches along the outer curve, and two feet five inches in circumference at its thickest part; another from Eschscholtz Bay was nine feet two inches in length, and two feet one and a half inches in circumference, and weighed one hundred and sixty pounds. A specimen, dredged up off Dungeness, measured eleven feet in length. In several of the instances of Mammoth's tusks from British strata, the ivory has been so little altered as to be fit for the purposes of manufacture; and the tusks of the Mammoth, which are still better preserved in the frozen drift of Siberia, have long been collected in great numbers as articles of commerce.[4]

In a specimen of the extinct Indian Elephant (*Elephas ganesa*, Fr. and C.) preserved in the British Museum, the tusks are ten feet six inches in length, and in consequence of their small amount of curvature, they project eight feet five inches in front of the head. Their apparent disproportion to the size of the skull is truly extraordinary, and exemplifies the maximization of dental development. Cuvier[5] states that the Elephant of Africa, at least in certain localities, has large tusks in both sexes, and that the female of this species, which lived seventeen years in the menagerie of Louis XIV., had larger tusks than those in any Indian Elephant, male or female, of the same size which he had seen. The ivory of the tusks of the African Elephant is most esteemed by the manufacturer for its density and whiteness.

The molar teeth of the Elephant are remarkable for their great size, even in relation to the bulk of the animal, and for the extreme complexity of their structure (fig. 141). The crown, of which a great proportion is buried in the socket, and very little more than the grinding surface appears above the gum, is deeply divided into a number of transverse perpendicular plates, consisting each of a body of dentine (*d*), coated by a layer of enamel (*e*), and this again by the less dense bone-like substance (*c*) which fills the interspaces of the enamelled plates, and here more especially merits the name of "cement," since it binds together the several divisions of the crown, as at *c*, before they are fully formed and united by the confluence of their bases into a common body of dentine. As the growth of each plate begins at the summit, they remain detached, and like so many separate teeth or denticles, as at the back part of fig. 141, until their base is completed, when it becomes blended with the bases of contiguous plates to form the common body of the crown of the complex tooth, from which the roots are next developed. The plates of the molar teeth of the Siberian Mammoth (*Elephas primigenius*, fig. 142) are thinner in proportion to their breadth, and more numerous in proportion to the size of the crown, than in the existing species of Asiatic Elephant (fig. 143).

In the African Elephant (fig. 144), on the other hand, the lamellar divisions of the crown are fewer and thicker, and they expand from the margins to the centre of the tooth, yielding a lozenge form when cut or worn transversely, as in mastication.

Develop-ment.

The horizontal as well as vertical course of development of the Elephant's grinder is well illustrated by the molar, the last of the lower jaw (fig. 141). The separate digital processes of the posterior plates are still distinct, and adhere only by the remaining cement. A little in advance we see them united to form the transverse plate

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[1] See Mr Corse's Memoir on the Teeth of the Elephant, in the *Philosophical Transactions*, 1799, p. 211. A good figure of the deciduous tusk is given in plate 5.

[2] Osteol. Series, No. 2757. The writer is indebted to the distinguished traveller, Dr Livingstone, for a similar tusk of an African Elephant, from the Zambesi district.

[3] *History of British Fossil Mammals*, 8vo, p. 247.

[4] In the account of the Mammoth's bones and teeth of Siberia, published in the *Philosophical Transactions* for 1737 (No. 446), tusks are cited which weighed two hundred pounds each, and "are used as ivory to make combs, boxes, and such other things; being little more brittle and easily turning yellow by weather and heat." From that time to the present there has been no intermission in the supply of ivory furnished by the tusks of the extinct Elephants of a former world.

[5] *Loc. cit.* p. 55.

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(*g*, *g*), and at the opposite extremity of the tooth the common base of dentine (*d*) is exposed, by which the plates are finally blended into one individual complex grinder.[1] This never takes place simultaneously along the whole extent of the tooth in the Indian Elephant.

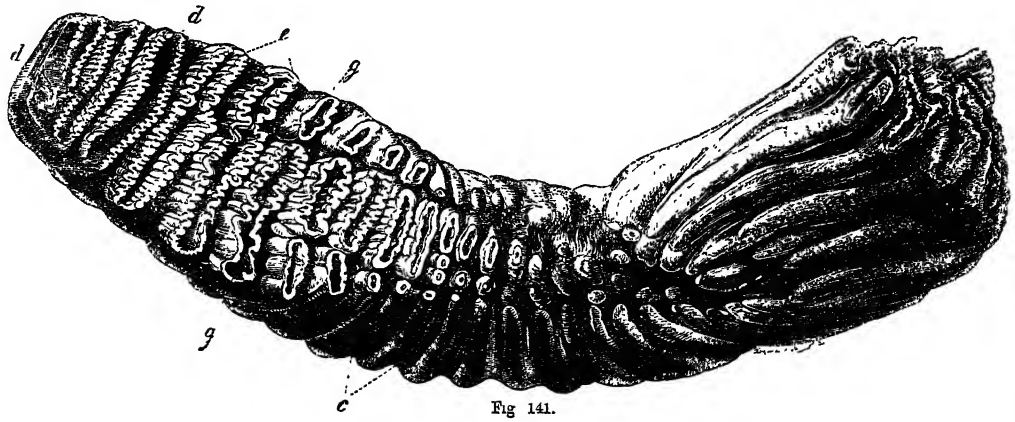

Fig 141.

Last Lower Grinder, Elephant.

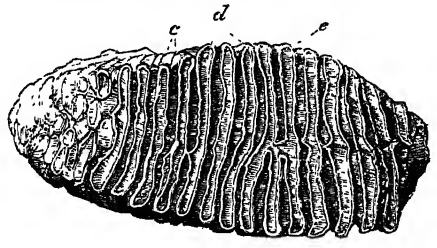

Fig. 142.

Upper Grinder of the Mammoth, (*Elephas primigenius*).

The African species manifests a closer affinity to the Mastodon by the basal confluence of the plates before the anterior ones are worn out.

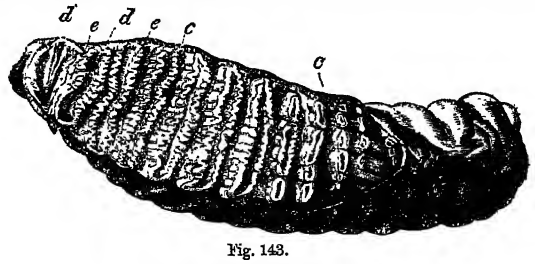

Fig. 143.

Upper Molar, Asiatic Elephant.

The formation of each grinder begins with the summits of the anterior plate, and the rest are completed in succession; the tooth is gradually advanced in position as its growth proceeds, and in the existing Indian Elephant, the anterior plates are brought into use before the posterior ones are formed. When the complex molar cuts the gum the cement is first rubbed off the digital summits, then their enamel cap is worn away, and the central dentine comes into play with a prominent enamel ring; the digital processes are next ground down to their common uniting base, and a transverse tract of dentine, with its wavy border of enamel, is exposed; finally, the transverse plates themselves are abraded to their common base of dentine, and a smooth and polished tract of that substance is produced. From this basis the roots of the molar are developed, and increase in length to keep the worn crown on the grinding level until the reproductive force is exhausted.

Fig 144.

Upper Molar, African Elephant.

When the whole extent of a grinder has successively come into play, its last part is reduced to a long fang supporting a smooth and polished field of dentine, with perhaps a few remnants of the bottom of the enamel folds at its hinder part.

When the complete molar has been thus worn down to a uniform surface, it becomes useless as an instrument for grinding the coarse vegetable substances on which the Elephant subsists; it is attacked by the absorbent action, and the wasted portion of the molar is finally shed. The grinding teeth of the Elephant progressively increase in size and in the number of lamellar divisions from the first to the last, and as the rate of increase in both respects is nearly identical in both jaws, they are here described as they appear in the lower one (fig. 141).

Succession.

The *first molar*, which cuts the gum in the course of the second week after birth, has a subcompressed crown nine-lines in antero-posterior diameter, divided by three transverse clefts into four plates, the third being the broadest, and the tooth here measuring six lines across. The first and second plates have two mamilloid summits, the third and fourth have three or four such; there is a single and sometimes a double mamilloid summit at the fore and back part of the crown, and the base slightly contracts, and forms a neck as long as the enamelled crown, but of less breadth, and this divides into anterior and posterior long, subcylindrical, diverging, but mutually incurved fangs; the total length of this tooth is one inch and a half. The corresponding upper molar, which Mr Corse describes as cutting the gum a little earlier than the lower one, has the anterior process or mammilla, and the posterior talon, developed into a fifth plate, smaller than the fourth, with which its middle part is confluent; the neck of this tooth is shorter, and the two fangs are shorter, larger, and more compressed, than those of the lower first molar. This tooth is the homologue of the deciduous molar (fig. 139, *d* 2) in the Mastodon and other Ungulates; it is not a mere miniature of the great molars of the mature animal, but retains, agreeably with the period of life at which it is developed, a character much more nearly approaching that of the ordinary pachydermal molar, manifesting the adherence to the more general type by the minor complexity of the crown, and by the form and relative size of the fangs. In the transverse divisions of the crown we perceive the affinity to the Tapiroid type, the different links connecting which with the typical Elephants are supplied by the extinct Lophiodons, Dinotheriums, and Mastodons. The subdivision of the summits of the primary plates recals also the character of the molars, especially the smaller ones, of the Phacochere in the Hog tribe. As the Elephant advances in age, the molars rapidly acquire their more special and complex character. The first molars are completely in place and in full use at three months, and are shed when the Elephant is about two years old.

The sudden increase and rapid development of the *second molar* answering to *d* 3 in fig. 139, may account for the non-existence of any vertical successor to the former tooth, or "premolar," in the Elephant. The eight or nine plates of the crown of this tooth are formed in the closed alveolus, behind the first molar, by the time this cuts the gum, and they are united with the body of the tooth, and most of them in use, when the first molar is shed. The average length of the second molar is two inches and a half, ranging from two inches to two inches and nine lines; the greatest breadth, which is behind the middle of the tooth, is from one inch to one inch three

[1] Some anatomists have described the divisions of the crown of the Elephant's grinder as so many "distinct teeth," and Mr Corse (loc. cit. p. 213), who first propounded this view, calls each complex grinder "a case of teeth," and states, "that these teeth are merely joined to each other by an intermediate softer substance acting like cement." But this statement applies only to the incompletely formed tooth; and the detached eminences of each individual plate, or of the crown of any complex tooth, at that stage of growth when they are held together only by the still uncalcified supporting matrix, might reasonably be regarded as so many distinct teeth.

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lines. There are two roots; the cavity of the small anterior one expands in the crown, and is continued into that of the three anterior plates. The thicker root supports the rest of the tooth; the second molar is worn out and shed before the beginning of the second year.

The *third molar*, answering to *d* 4 in fig. 139, has the crown divided into from eleven to thirteen plates; it averages four inches in length and two inches in breadth, and has a small anterior, and a very large posterior root. It begins to appear above the gum about the end of the second year, is in its most complete state and extensive use during the fifth year, and is worn out and shed in the ninth year.

The *fourth molar*, answering to *m* 1 in fig. 139, presents a marked superiority of size over the third, and a somewhat different form. The anterior angle is more obliquely abraded, giving a pentagonal figure to the tooth in the upper jaw. The number of plates in the crown of this tooth is fifteen or sixteen; its length between seven and eight inches, its breadth three inches. It has an anterior simple and slender root supporting the three first plates; a second of larger size and bifid, supporting the four next plates; and a large contracting base for the remainder. The forepart of the grinding surface of this tooth begins to protrude through the gum at the sixth year; the tooth is worn away, and its last remnant shed, about the twentieth or twenty-fifth year. It is the homologue of the first true molar of ordinary Pachyderms.

The *fifth molar*, answering to *m* 2 in fig. 140, with a crown of from seventeen to twenty plates, measures between nine and ten inches in length, and about three inches and a half in breadth. The second root is more distinctly separated from the first simple root than from the large mass behind. It begins to appear above the gum about the twentieth year; its duration has not been ascertained by observation, but it probably is not shed before the sixtieth year.

The *sixth molar*, answering to *m* 3 in fig. 140, is the last, and has from twenty-two to twenty-seven plates; its length, or antero-posterior extent, following the curvature, is from twelve to fifteen inches; the breadth of the grinding surface rarely exceeds three inches and a half.

The reproductive power of the matrix in some cases surpasses that of the formative development of the cavity for lodging the tooth, and the last lamellæ are obliged to be folded from behind forwards upon the side of the tooth. Fig. 141 shows this condition in the last lower molar.

One may reasonably conjecture that the sixth molar of the Indian Elephant, if it make its appearance about the fiftieth year, would, from its superior depth and length, continue to do the work of mastication until the ponderous Pachyderm had passed the century of its existence.

The molars succeed each other from behind forwards, moving, not in a right line, but in the arc of a circle. The position of the growing tooth in the closed alveolus is almost at right angles with that in use. The grinding surface being at first directed backwards in the upper jaw, and forwards in the lower jaw; and being brought by the revolving course into a horizontal line in both jaws, so that the molars duly oppose each other when developed for use. The imaginary pivot on which the grinders revolve is next their root in the upper jaw, and is next the grinding surface in the lower jaw; in both towards the frontal surface of the skull. Viewing both upper and lower molars as one complete whole, subject to the same revolving movement, the section dividing such whole into upper and lower portions, runs parallel to the curve described by that movement, the upper being the central portion, or that nearest the pivot, the lower the peripheral portion. The grinding surface of the upper molars is consequently convex from behind forwards, and that of the lower molars concave. The upper molars are always broader than the lower ones. The bony plate forming the sockets of the growing teeth is more than usually distinct from the body of the maxillary, and participates in this revolving course, advancing forwards with the teeth. The partition between the tooth in use and its successor is perforated near the middle, and in its progress forwards that part next the grinding surface is first absorbed, the rest disappearing with the absorption of the roots of the preceding grinder.

Structure.

There are few examples of organs that manifest a more striking adaptation of a highly complex and beautiful structure to the exigencies of the animal endowed with it, than the grinding teeth of the Elephant. We perceive, for example, that the jaw is not encumbered with the whole weight of the massive tooth at once, but that it is formed by degrees as it is required; the division of the crown into a number of successive plates, and the subdivision of these into cylindrical processes, presenting the conditions most favourable to progressive formation. But a more important advantage is gained by this subdivision of the tooth; each part is formed like a perfect simple tooth, having a body of dentine, a coat of enamel, and an outer investment of cement. A single digital process may be compared to the simple canine of a Carnivore; a transverse row of these, therefore, when the work of mastication has commenced, presents, by virtue of the different densities of their constituent substances, a series of cylindrical ridges of enamel, with as many depressions of dentine, and deeper external valleys of cement; the more advanced and more abraded part of the crown is traversed by the transverse ridges of the enamel inclosing the depressed surface of the dentine, and separated by the deeper channels of the cement; the forepart of the tooth exhibits its least efficient condition for mastication; the inequalities of the grinding surface being reduced in proportion as the enamel and cement which invested the dentinal plates have been worn away: this part of the tooth is, however, fitted for the first coarse crushing of the branches of a tree; the transverse enamel ridges of the succeeding part of the tooth divide it into smaller fragments, and the posterior islands and tubercles of enamel pound it to the pulp fit for deglutition. The structure and progressive development of the tooth not only give the Elephant's grinder the advantage of the uneven surface which adapts the millstone for its office, but, at the same time, secure the constant presence of the most efficient arrangement for the finer comminution of the food at the part of the mouth which is nearest the throat.

Teeth of Mammals.

With regard to the *microscopic structure* of the peculiar modification of dentine called "ivory," this is characterised partly by the minute size of the tubes, which, at their origin from the pulp-cavity, do not exceed $\frac{1}{1500}$th of an inch in diameter; in their close arrangement, at intervals scarcely exceeding the breadth of a single tube; and, above all, on their strong and almost angular gyrations, which are much greater than the secondary curvatures of the tubes of ordinary dentine.

The dentinal tubes of ivory, as they radiate from the pulp-cavity, incline obliquely towards the pointed end of the tusk, and describe two slight primary curves—the first convex towards that end, the second and shorter one concave. These curves, in narrow sections from near the open base of the tusk, are almost obscured by the strong angular parallel secondary gyrations. The tubes divide dichotomously, at acute angles. and gradually decrease in size as they approach the periphery of the tusk.

The characteristic appearance of decussating curved striæ, with oblique rhomboidal spaces, so conspicuous on transverse sections or fractures of ivory, is due to the refraction of light caused by the parallel secondary gyrations of the tubes above described. The strong contour lines observed in longitudinal sections of ivory, parallel with the cone of the pulp cavity, and which are smaller, circular, and concentric, when viewed in transverse slices of the tusk, are commonly caused by strata of minute opaque cellules, which are unusually numerous in the interspaces of the tubes throughout the substance of the ivory, and by their very great abundance and larger size in the peripheral layers of cement. The close-set lateral branches of the dentinal tubes unite with the tubuli of the cells. The decomposition of the fossil tusk into superimposed conical layers takes place along the strata of the opaque cellules, and directly across the course of the gyrating dentinal tubes. By the minuteness and close arrangement of the tubes, and especially by their strongly undulating secondary curves, a tougher and more elastic tissue is produced than results from their disposition in ordinary dentine; and the modification which distinguishes "ivory" is doubtless essential to the due degree of coherence of so large a mass as the elephant's tusk, projecting so far from the supporting socket, and to be frequently applied in dealing hard blows and thrusts. The central part of the tusk, especially near the base of such as have reached their full size, is occupied by a slender cylindrical tract of modified ivory, perforated by a few vascular canals, which is continued to the apex of the tusk. It is not uncommon to find processes of osteo-dentine or imperfect bone-like ivory, projecting in a stalactitic form[1] into the interior of the pulp-cavity.

The musket-balls and other foreign bodies which are occasionally found in ivory, are immediately surrounded by osteo-dentine, in greater or less quantity.[2] It has often been a matter of wonder how such bodies should become completely imbedded in the substance of the tusk, sometimes without any visible aperture, or how leaden bullets may have become lodged in the solid centre of a very large tusk without having been flattened. The explanation is as follows:—A musket-ball, aimed at the head of an elephant, may penetrate the thin bony socket and the thinner ivory parietes of the wide conical pulp-cavity occupying the inserted base of the tusk. The hole is soon healed and filled up, by ossification of the periosteum of the socket and of the pulp next the thin wall of ivory which has been perforated. The ball sinks below the level of this cicatrix, and the presence of the foreign body exciting inflammation of the pulp, an irregular course of calcification ensues, which results in the deposition around the ball of a certain thickness of osteo-dentine. The pulp, then resuming its healthy character and functions, coats the surface of the osteo-dentine, inclosing the ball, together with the rest of the conical cavity into which that mass projects, with layers of normal ivory. By the continued progress of growth the ball so inclosed is carried forwards to the middle of the solidified part of the tusk.

[1] Haller seems to have been the first to notice these irregular internal deposits in the pulp-cavity of the elephant's tusk. *Elementa Physiologiæ*, tom. viii. p. 519.

[2] Cuvier, *Annales du Muséum*, tom. viii. p. 115 (1806). Goodsir, *Edinb. Philos. Trans.*, 1841, p. 97.

Teeth of Mammals.

Should the ball have penetrated the base of the tusk of a young elephant, it may be carried forwards by the uninterrupted growth and wear of the tusk, until that base has become the apex, and be finally exposed and discharged by the continual abrasion to which the apex of the tusk is subjected.

Yet none of these phenomena prove the absolute non-vascularity of the tusk, but only the low degree of its vascularity. Blood circulates, slowly no doubt, through the prolongations of the pulp in the minute vascular canals which are continued through the centre of the ivory to the very apex of the tooth. And it is from this source that the fine tubular structure of the ivory obtains the correspondingly minute villi carrying the plasmatic colourless fluid by which its low vitality is maintained.

The matrix of the tusk consists of a large conical pulp, which is renewed quicker than it is converted, and thus is not only preserved, but grows up to a certain period of the animal's life. It is lodged in the cavity at the base of the tusk; this base is surrounded by the remains of the capsule—a soft vascular membrane of moderate thickness—which is confluent with the border of the base of the pulp, where it receives its principal vessels. The writer had the tusk and pulp of the great elephant at the Zoological Gardens longitudinally divided, soon after the death of that animal in 1847. Although the pulp could be easily detached from the inner surface of the pulp-cavity, it was not without a certain resistance; and when the edges of the co-adapted pulp and tooth were examined by a strong lens, the filamentary processes from the outer surface of the pulp could be seen stretching, as they were withdrawn from the dentinal tubes before they broke. They are so minute that, to the naked eye, the detached surface of the pulp seems to be entire, and Cuvier was thus deceived in concluding that there was no organic connection between the pulp and the ivory.

Each molar of the Elephant is formed in the interior of a membranous sac—the capsule, the form of which partakes of that of the future tooth, being cubical in the first molar, oblong in the last, and rhomboidal in most of the intermediate teeth; but always decreasing in vertical extent towards its posterior end, and closed at all points, save where it is penetrated by vessels and nerves. It is lodged in an osseous cavity of the same form as itself, and usually in part suspended freely in the maxillary bone; the bony socket being destined to form part of the socket of the tooth, the exterior of the membranous capsule is simple and vascular; its internal surface gives attachment to numerous folds or processes, as in most other Ungulate animals. The dentinal pulp rises from the bottom of the capsule, or that part which lines the deepest part of the alveolus, in the form of transverse parallel plates, extending towards that part of the capsule ready to escape from the socket. These plates adhere only to the bottom of the capsule; their opposite extremity is free from all adhesion. This summit is thinner than the base; it might be termed the edge of the plate, but it is notched or divided into many digital processes. The tissue of these digitated plates is identical with that of the dentinal pulp of simple mammalian teeth; it becomes also highly vascular at the parts where the formation of the dentine is in active progress. Processes of the capsule descend from its summit into the interspaces of the dentinal pulp-plates, and consequently resemble them in form; but they adhere not only by their base to the surface of the capsule next the mouth, but also by their lateral margins to the sides of the capsule, and thus resemble partition-walls, confining each plate of the dentinal pulp to its proper chamber; the margin of the partition opposite its attached base is free in the interspaces of the orifices of the dentinal pulp-plates. The enamel organ, which Cuvier appears to have recognised under the name of the internal layer of the capsule, is distinguished by its light blue subtransparent colour and usual microscopic texture.

For the details of the action of those parts of the complex matrix in the formation of the several tissues of the grinding tooth of the Elephant, reference may be made to the *Ossemens Fossiles*[1] of Cuvier and the writer's *Odontography*,[2] in which the theories of excretion and conversion may be contrasted.

Section IV.—*Application of Odontology to Classification.*

True teeth being restricted to the Vertebrate classes, their application to zoology is proportionally limited; but in them they form more or less important, if not essential, aids to the classification and grouping of species.

In this relation, however, as zoological characters, teeth possess different degrees of value in different classes, the lowest degree being in the class of Fishes, and the highest in that of Mammals.

Numerous rows of teeth, gradually succeeding and displacing each other, characterise the higher organized, or Plagiostomous Fishes, and particular modifications of form and size of their teeth distinguish the primary subdivisions of the Plagiostomous order. A few other groups are well defined by dental characters, as the Pycnodonts, Gymnodonts, Goniodonts, and Chætodonts. The teeth afford good characters for the sub-division of the Sea Bream (*Sparidæ*), and Cuvier[3] has availed himself of dental characters to establish four tribes of that natural family. But in most of the natural orders, and in many of the subordinate groups, the dental system is subject to very great diversity in regard to the form, number, and position of the teeth; and in some natural groups of Fishes, there is also a want of constancy in the structure of the teeth. There are extremely few genera of Fishes that can be characterised by a definite numerical dental formula, like that which is applicable to most of the Mammalian genera. Indeed, in the first introduction of true teeth into the animal series, regarded in the ascending order, they manifest, like the mouths of the *Polypi*, the stomachs of the *Polygastria*, the gills of the Nereids, and the generative organs of the *Tæniæ*, the principle of vegetative or irrelative repetition; and in many fishes are too numerous to be counted. The limits within which the teeth are applicable as means of classification in Fishes, have been attempted to be defined in the writer's *Odontography*. Traced from species to species, they are of great importance in the determination of the fossils of this class.

Teeth of Mammals.

With regard to microscopic structure, certain of the modifications of dental tissues, defined in the introductory section of the present Essay, are peculiar to, and characteristic of, the piscine class. Unvascular, or fine-tubed dentine, forms the crown of the teeth in a few Fishes, but is more common in those of the higher classes, in which, however, it is always associated with enamel or cement, or with both substances.

With regard to the class *Reptilia*, the teeth serve to characterize smaller and more definite groups, as, *e. g.*, the venomous and non-venomous Ophidians, the acrodont, pleurodont, and thecodont Saurians. Certain genera, and even species, may likewise be known by peculiar forms of teeth; but these are exceptions, and it is rarely that a definite dental formula can be assigned as a generic character of a reptile. There is no decided modification of dental structure peculiar to any of the class of reptiles; the poison-fang is rather a modification of form. The labyrinthic structure reaches its maximum of complexity in the great extinct Sauroid Batrachianis of the Keuper sand-stone, but "it also exists at the base of the tooth in a few fishes,"[4] and specific instances of it in that class (*Lepidosteus* and a few other Sauroids) have since received illustrations in the works of Professor Agassiz[5] and Dr Wyman.[6]

The only constant and general character of the teeth of the cold-blooded classes of *Vertebrata* is derivable from the brief period of their existence in the individual, so that the few which develop roots have these always simple and undivided, usually hollow, and with the germ of a successor in or near them.

With the exception of the composite dental masses of the Chimæroids and the anomalous rostral teeth in *Pristis*, no existing species of fish or reptile could be said to have permanent teeth: no extinct species of either class has yet been found with teeth having divided roots implanted in sockets; and the sole evidence of perpetual growth by a persistent pulp, has but lately been given by the singular extinct Saurians of South Africa, with two long canine tusks in the upper jaw, which must have grown and been maintained throughout life, of due size and strength; like the tusks of the Boar and Walrus.[7]

Dicynodon.

In the mammalian class the value of the dental organs, as characters of classification, is much greater than in reptiles or fishes. Yet there is a difference in this respect in the different orders, and the dental system of the monophyodont *Cetacea* and *Bruta* has a much greater range of variation, and a less constant relation to the other characters on which the families and genera are founded, than in the diphyodont species. But, with respect to these also, the value of the teeth as zoological characters has been over-rated.[8]

It is true, indeed, that the most manifestly natural mammalian genera are those, the species of which are provided with absolutely similar molar teeth, and that those genera which include species with molars of different forms do not present the same character of unity. It does not follow, however, that by combining species of mammals with similar molars, a group will be formed perfectly analogous to those which may be considered as the most natural. Neither the molar teeth nor any other solitary character will serve to establish a natural classification.

The molar teeth will least mislead in this respect where their modification is most extreme, as when they are adapted to divide the flesh of animals, in which case they must of necessity be associated with the faculties and instruments for seizing and destroying prey.

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[1] Ed. 1835, 8vo, tom. i. pp. 514, 869.
[2] 4to, 1841-5, pp. 645-655.
[3] *Histoire des Poissons*, tom. vi. p. 5.
[4] *Odontography*, 1841, chap. ii., p. 201.
[5] *Poissons Fossiles, Notice sur les Sauroides*, Janvier, 1843.
[6] *Trans. Boston Society of Natural History*, August 1843.
[7] *Geological Transactions*, 2d series, vol. vii.
[8] M. F. Cuvier says:—"Cette recherche me fit reconnaître que tous les genres manifestement naturels, et admis comme tels par tous les Naturalistes, étaient formés d'espèces pourvues de machelières absolument semblables; que ceux qui comprenaient des espèces dont les mâchelières différaient, n'offraient point ce caractère d'unité qui était le partage des premiers; et, enfin, qu'en réunissant les espèces à mâchelières semblables on reformait des groupes parfaitement analogues à ceux que l'on pouvait considérer comme les plus parfaits." *Dents de Mammifères*, 8vo., 1825, p. ix.

Teeth of Mammals.

But molar teeth may be similarly modified, and equally well adapted, for crushing vegetable substances, which substances may be sought for by one species on the dry land, by a second in marshes, and by a third in the sea, or on the banks of rivers. The grinding surface of the molar tooth, for example, may for this purpose be elevated into a pair of transverse ridges, and we find such molars in the Kangaroo, the Tapir, and the Manatee, as also in the extinct *Diprotodon*, *Nototherium*, and *Dinotherium*. The small anterior molars of the *Mastodon giganteus* likewise present this form. It would be difficult to select, from the Mammalian class, the constituents of a more heterogeneous group than would be constituted by the character which M. F. Cuvier has assigned as the true guide to the formation of the most natural and uniform genera in Mammalogy.

Even in regard to teeth adapted to carnivorous habits, were these characters to form the sole guides in classification, species of placental Mammalia would be associated with those of the implacental subclass; and M. F. Cuvier, in illustrating his generalization, observes:—"Les sarigues, les péramèles, et les dasyures se sont réunis aux Insectivores, &c. &c., et je crois avoir été conduit à ces modifications par des motifs légitimes."[1]

The molar teeth, which are best adapted for dealing with vegetable food, as in the Rodents and the hoofed Mammals, shew modifications of the enamel-markings of the grinding surface which are characteristic of families, of genera, and, in many instances, of species; and which are of the greatest utility to the Palæontologist from their conspicuous and well-marked features, and their constancy.

It is interesting also to observe, that in their more general appearance, the patterns of the upper molars are more symmetrical in the *Ungulata*, with hoofs in even numbers (compare figs. 115, 118, 120, 125), than in those with hoofs in odd numbers (compare figs. 117, 130, 132).

Sect. IV.—HOMOLOGIES OF THE TEETH.

Homologies of the Teeth.

The idea of a recognition of answerable teeth in different animals has prevailed, more or less vaguely, in Anatomy, from an early period of the science.

When "incisors," "canines," and "molars" were predicated of the dentition in different species, homologous teeth were recognised so far as the characters of those classes of teeth were defined and understood.

The Cuviers[2] went a step further, and distinguished the molar teeth into "false" and "true," into "carnassial" and "tubercular." De Blainville pointed out a particular tooth by the name of "principal," which he believed himself able to trace from species to species.[3]

The results of the writer's researches into the homologies of the teeth are given in his *Odontography* in the *Transactions of the British Association* for 1839, and in those of the *Royal Society* for 1850, p. 481.

The first step in this inquiry is the elimination of those classes of *Vertebrata* and orders of *Mammalia* in which homology cannot be predicated of individual teeth. This limits the work to the group of Mammals which the writer has termed "Diphyodonts."

Only in the Mammalian orders with two sets of teeth do those organs acquire fixed individual characters, supporting the application of special denominations; and this individualization of the teeth is eminently significative of the high grade of organization of the animals manifesting it.

Originally, indeed, the name "incisors," "laniaries" or "canines," "molars," "false molars," were given to the teeth in Man and certain Mammals, as in Reptiles, in reference merely to the shape and offices so indicated; but names of teeth can now be used as arbitrary signs, in a more fixed and determinate sense. In some *Carnivora*, *e.g.*, the front teeth have broad tuberculate summits, adapted for nipping and bruising, while the principal back-teeth are shaped for cutting, and work upon each other like the blades of scissors. The front teeth in the Elephant project from the upper jaw in the form, size, and direction of long pointed horns. In short, shape and size are the least constant of dental characters; and the homologous teeth are determined, like other parts, by their relative position, by their connections, and by their development.

Homologies of the Teeth.

Those teeth which are implanted in the premaxillary bones, and in the corresponding part of the lower jaw, are called "incisors," whatever be their shape or size. The tooth in the maxillary bone, which is situated at, or near to, the suture with the premaxillary, is the "canine," as is also that tooth in the lower jaw which, in opposing it, passes in front of its crown when the mouth is closed. The other teeth of the first set are the "deciduous molars;" the teeth which displace and succeed them vertically are the "premolars;" the more posterior teeth, which are not displaced by vertical successors, are the "molars," properly so called.

The premolars must displace deciduous molars in order to rise into place; the molars have no such relations. It will be observed in fig. 17 that the last deciduous molar (*d* 4) has the same relative superiority of size to *d* 3 and *d* 2 which *m* 3 bears to *m* 2 and *m* 1; and the crowns of *p* 3 and *p* 4 are of a more simple form than those of the milk-teeth which they are destined to succeed. This, however, is not a constant or essential character. Teeth of each of the kinds arbitrarily termed "incisors," "canines," "false molars," and "molars," have received other special names, having reference to certain peculiarities of form or other property. The "false molars" in the human subject have been called "bicuspids." The last upper premolar and the first true molar in the *Carnivora* are termed "sectorials," or "molaires carnassières." Teeth of an elongated conical form, projecting considerably beyond the rest, and of uninterrupted growth, are called "tusks;" such, for example, are the incisors of the Elephant, Narwhal, Dinotherium, and Dugong, the canines of the Boar, Walrus, and Hippopotamus. The long and large incisors of the Rodents have been termed, from the shape and structure of their cutting edge, scalpriform teeth, chisel teeth, "*dentes scalprarii*." The lower incisors of the Flying Lemurs (*Galeopithecus*), with the crown deeply notched like a comb, are termed "*dentes pectinati*." The canines of the Baboons, which are deeply grooved in front like the poison-fangs of some snakes, are "dentes canaliculati." The compressed crowns of the teeth of short-clawed Seals (*Stenorhynchus*) and of the extinct *Zeuglodon*, being divided into points like a saw, are "*dentes serrati*," etc. But a true knowledge of nature, a right appreciation of what is essential in her phenomena, tends to explode needless terms of art invented for unimportant varieties, and to establish those terms that are the signs of true species of things.

As most zoologists have adopted the Cuvierian system of nomenclature and homology of the teeth in Mammalia, it may not be superfluous to explain what is here deemed objectionable in that system. In it the molar series of teeth, or those that follow the canines, are divided, according to their form, into three kinds, "false molars," "carnassials," and "tubercular molars," and the generic dental characters of the Mammalia are formulized according to this system. Thus, the genus *Felis* has—"fausses molaires" $\frac{2.2}{2.2}$, "carnassières" $\frac{1.1}{1.1}$, "tuberculeuses" $\frac{1.1}{0.0} = \frac{8}{6}$. This seems a true and natural way of expressing the homotypal teeth, or the answerable teeth in the upper and lower jaw. But to illustrate its error, the subjoined diagram (fig. 145) is appended, in which the dental

[1] *Loc. cit.*, p. xi. [2] G. Cuvier, *Leçons d'Anatomie Comparée*, tom. iv. (1836). F. Cuvier, *Dents des Mammifères*, 8vo. p. 77.
[3] *Ostéographie des Mammifères*, tom. i. p. 43. [4] *Ossemens Fossiles*, 8vo. 1835, tom. vii. p. 14. *Dents des Mammifères*, p. 77.

Homologies of the Teeth.

system of the Cat-tribe (*Felis* V.) is associated with that of other Mammals, and in which the line marked "*Cuvier*" intersects the teeth in each jaw, called "carnassières," those anterior to them being the teeth called

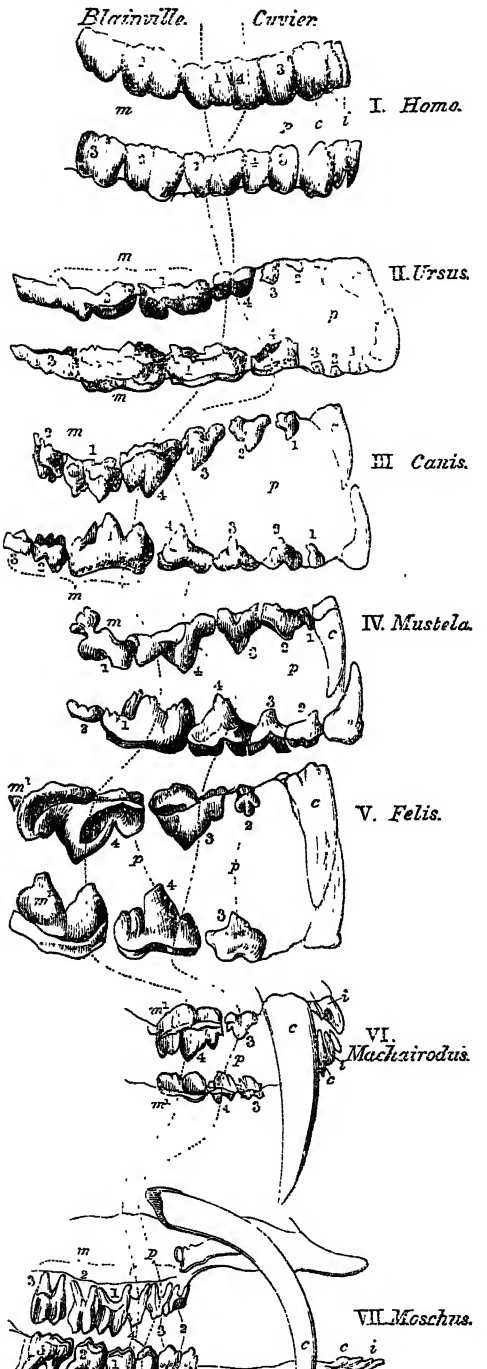

Fig. 145.
Homologies of Teeth.

"fausses molaires;" those behind—a single tooth in the upper jaw of *Felis*—being the "tuberculeuses." In this genus the tooth (*p* 4) above chiefly plays upon the tooth (*m* 1) below, which has a similar sectorial or carnassial modification of form; they fit, indeed, almost as Cuvier describes, like the blades of a pair of scissors. The two teeth in advance of the carnassial in the upper jaw (*p* 3, *p* 2) in like manner are opposed to the same number of "fausses molaires" in the under jaw, and the canine (*c*) above plays upon the canine below; all seems fitting and symmetrical, save that the little tubercular (*m* 1) above has no opponent in the lower jaw. And, perhaps, the close observer might notice that, whilst the upper canine (*c*) glides behind its homotype below, the first upper false molar (*p* 2) passes anterior to the crown of the first false molar (*p* 3) below; and that the second false molar and carnassial of the upper jaw are also a little in advance of those teeth in the under jaw when the mouth is shut.

Homologies of the Teeth.

In passing to the dentition of the Dog (fig. III. *Canis*), formulized by Cuvier as "fausses molaires $\frac{3.3}{4.4}$, carnassières $\frac{1.1}{1.1}$, tuberculeuses $\frac{2.2}{2.2} = \frac{12}{14}$,"[1] it will be observed that here the first upper false molar (*p* 1) differs from the first (*p* 2) in *Felis*, inasmuch as, when the mouth is shut, it preserves the same relative position to its opponent below (*p* 1, in fig. III.) which the upper canine does to the lower canine, and that the same may be said of the second and the third false molars; but that, with regard to the carnassial above (*p* 4), this tooth repeats the same relative position in regard to the fourth false molar below (*p* 4), and not to that tooth (*m* 1) which Cuvier regarded as the lower homotype of the carnassial; and, indeed, the more backward position of the lower carnassial is so slight that its significance might well be overlooked, more especially as the two succeeding tubercular teeth above were opposed to two similar tuberculars below.

How unimportant size and shape are, and how significant relative position is, in the determination of the homologies of teeth as of other parts, may be learnt before quitting the natural order of Carnivora; *e. g.* by the condition of the dental system in the Bear (fig. II. *Ursus*). Here the lower tooth (*m* 1), instead of presenting the carnassial character, and resembling in form the upper tooth (*p* 4), which is the homologue of the upper carnassial in the dog, has a tubercular crown, and corresponds in size as well as shape with the upper tooth (*m* 1), to which it is almost wholly opposed, and with the same slight advance of position which we observe in the lower canine as compared with the upper one, and in the four lower premolars (*p* 1, *p* 2, *p* 3, *p* 4) as compared with their veritable homotypes above. F. Cuvier divides the molar series of the genus *Ursus* into "fausses molaires $\frac{3.3}{4.4}$, carnassières $\frac{1.1}{1.1}$, tuberculeuses $\frac{2.2}{2.2} = \frac{12}{14}$."[2] The tendency in every thinker to generalise and to recognise Nature's harmonies, has led him here to use the term "carnassière" in an arbitrary sense, and to apply it to a tooth above (II. *p* 4), which he owns has such a shape and diminished size as would have led him to regard it as merely a false molar, but that the upper carnassial would then have entirely disappeared; and it has also led him to give the name "carnassière" to a tooth below (*m* 1), which he, nevertheless, describes as having a tubercular and not a trenchant crown. In so natural a group as the true Carnivora, it was impossible to overlook the homologues of the trenchant carnassials of the lion, even when they had become tubercular in the omnivorous bear; and Cuvier, therefore, having determined and defined the teeth so called in the feline genus, felt compelled to distinguish them by the same names after they had lost their formal specific character. And if, indeed, he had succeeded in discovering the teeth which were truly answerable or homotypal in the upper and lower jaws, the term "carnassial" might have been retained as an arbitrary one for such teeth, and have been applied to their homologues in

[1] *Ossemens Fossiles*, tom. cit. p. 59. *Dents des Mammifères*, p. 95.

[2] Op. cit. p. 109.

Homologies of the Teeth.

Man, the Ruminant, or the Pachyderm, where they are as certainly determinable as in those aberrant Carnivores, in which they have equally lost their sectorial shape.

But the inconvenience of names indicative of such specialties of form will be very obvious when the term "tuberculeuses" comes to be applied to the three hindmost teeth in the *Hyænodon* (fig. 113), which teeth answer to the broad crushing teeth, *m* 1, *m* 2, and *m* 3, in the bear and some other existing *Carnivora*. The analogous term "molar" having a less direct or descriptive meaning, is therefore so much the better, as the requisite arbitrary name of a determinate species of teeth.

Had Cuvier been guided in his determinations of the teeth by their mutual opposition in the closed mouth, and had studied them with this view in the *Carnivora*, with the dentition most nearly approaching to the typical formula, viz. the bear, he could then have seen that the three small and inconstant lower premolars (*p* 1, *p* 2, *p* 3) were the homotypes of the three small and similarly inconstant premolars above; that the fourth false molar (*p* 4 below), which, as he observes, "alone has the normal form,"[1] was truly the homotype of the tooth above (*p* 4), which he found himself compelled to reject from the class of "fausses molaires," notwithstanding it presented their normal form; that the tubercular tooth (*m* 1) which he calls "carnassière" in the lower jaw, was the veritable homotype of his first "molaire tuberculeuse" above (*m* 1), and that the tooth in the inferior series, which had no answerable one above, was his second "tuberculeuse" (*m* 3) in the present Essay. The true second tubercular above (*m* 2) is, however, so much developed in the bear as to oppose both *m* 2 and *m* 3 in the lower jaw, and it might seem to include the homotypes of both those teeth coalesced. One sees with an interest such as only these homological researches could excite, that they were distinctly developed in the ancient *Amphicyon* (fig. 114), which accordingly presents the typical formula.

Thus the study of the relative position of the teeth of the bear might have led to the recognition of their real nature and homologies, and have helped to raise the mask of the extreme formal modifications, by which they are adapted to the habits of the more blood-thirsty *Carnivora*. But the truth is plainly and satisfactorily revealed when we come to trace the course of development and succession of these teeth. The weight which must ever attach itself to an opinion sanctioned by the authority of both the Cuviers, demands that a conclusion contrary to theirs, and which seems to be opposed by Nature herself in certain instances, should be supported by all the evidence of which such conclusion is susceptible.

It is proposed, therefore, first, to show how, in the bear, the writer's determinations of the teeth are established by their development, as well as by their relative position. As the question only concerns the molar series, the remarks will be confined to those teeth. In the jaws of the young bear, figured in cut 110, the first premolar is the only one of the permanent series in place; the other grinders in use are the deciduous molars, *d* 2, *d* 3, and *d* 4; *d* 2 will be displaced by *p* 2, *d* 3 by *p* 3, and *d* 4, by the tooth *p* 4, which, notwithstanding its size and shape, Cuvier felt himself compelled to discard from the series of false molars, but which we now see is proved by its developmental relations to *d* 4, as well as by its relative position and similarity to *p* 4 in the lower jaw (fig. 145, *Ursus*) to be veritably the last of the premolar series, and to agree not in shape only, but in every essential character, with the three preceding teeth called by Cuvier "fausses molaires." So, likewise, in the lower jaw, it is seen that the primitive deciduous series (*d* 1, *d* 2, *d* 3, and *d* 4) will be displaced by the corresponding premolars (*p* 1, *p* 2, *p* 3, and *p* 4); and that the tooth *m* 1, called carnassière by Cuvier, in the lower jaw, differs essentially from that (*p* 4) so called in the upper jaw, by being developed without any vertical predecessor or deciduous tooth.

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The same law of development and succession prevails in the genus *Canis*, as may be readily seen in the jaws of a dog of ten months' age. Although the tooth (*m* 1, III. fig. 145) in the lower jaw has exchanged the tubercular for the carnassial form, it is still developed, as in the bear, behind the deciduous series, and independently of any vertical predecessor; and the tooth (*p* 4) above, although acquiring a relative superiority of size to its homologue in the bear, and more decidedly a carnassial form, is not the homotype of the permanent carnassial below, but of that premolar (*p* 4) which displaces the deciduous carnassial (*d* 4). The symbols in fig. 145 III. sufficiently indicate the relations of the other teeth, and the conclusions that are to be drawn from them as to their homologies.

In the genus *Felis* (fig. 104), the small permanent tubercular molar of the upper jaw (*m* 1) has cut the gum before its analogue (*d* 4) of the deciduous series has been shed; but though analogous in function, this tooth is not homologous with, or the precedent tooth to *m* 1, but precedes the great carnassially modified premolar (*p* 4). In the lower jaw the tooth (*m* 1) which is functionally analogous to the carnassial above, is also, as in the dog, the first of the true molar series, and the homotype of the little tubercular tooth (*m* 1) above. And the homologies of the permanent teeth (*p* 4 and *m* 1 below, fig. 145, V.), with those so symbolised in the dog (fig. 145, III.), teach us that the teeth which are wanting in the feline, in order to equal the number of those in the canine dentition, are *m* 2 in the upper jaw, *m* 2 and *m* 3 in the lower jaw; *p* 1 in the upper jaw, *p* 1 and *p* 2 in the lower jaw; thus illustrating the rule, that, when the molar series falls short of the typical number, it is from the two extremes of such series that the teeth are taken, and that so much of the series as is retained is thus preserved unbroken. In the great extinct sabre-toothed tiger (*Machairodus*, fig. 145, VI.[2]), the series is still further reduced by the loss of *p* 2 in the upper jaw.

That the student may test for himself the demonstration which the developmental characters above defined yield of the true nature and homologies of the feline dentition, the most modified of all in the terrestrial *Carnivora*, he is recommended to compare with Nature the following details of the appearance and formation of the teeth in the common cat. In this species the deciduous incisors (*d i*) begin to appear between two and three weeks old; the canines (*d c*) next, and then the molars (*d m*) follow, the whole being in place before the sixth week. After the seventh month they begin to fall in the same order; but the lower sectorial molar (*m* 1) and its tubercular homotype above (*m* 1) appear before *d* 2, *d* 3, and *d* 4 fall. The longitudinal grooves are very faintly marked in the deciduous canines. The first deciduous molar (*m* 2) in the upper jaw is a very small and simple one-fanged tooth; it is succeeded by the corresponding

[1] *Dents des Mammifères*, p. 111.

[2] *Machairodus*, from μάχαιρα, a sabre; and ὀδούς, a tooth. This generic name was imposed by Dr Kaup on the extinct animal which was armed with canine teeth, like that in the above figure (*c*). Such teeth, long, compressed, falciform, sharp-pointed, and with anterior and posterior finely-serrated edges, were first discovered in tertiary strata in Italy and Germany, and were referred by Cuvier to a species of bear, under the name of *Ursus cultridens*.

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tooth of the permanent series, which answers to the second premolar (*p* 2) of the hyæna and dog. The second deciduous molar (*m* 3) is the sectorial tooth; its blade is trilobate, but both the anterior and posterior smaller lobes are notched, and the internal tubercle, which is relatively larger than in the permanent sectorial, is continued from the base of the middle lobe, as in the deciduous sectorial of the dog and hyæna; it thus typifies the form of the upper sectorial, which is retained in the permanent dentition of several Viverrine and Musteline species. The third or internal fang of the deciduous sectorial is continued from the inner tubercle, and is opposite the interspace of the two outer fangs. The Musteline type is further adhered to by the young Feline in the large proportional size of its deciduous tubercular tooth (*d* 4). In the lower jaw, the first milk-molar (*d* 3) is succeeded by a tooth (*p* 3) which answers to the third lower premolar in the dog and civet. The deciduous sectorial (*d* 4), which is succeeded by the premolar (*p* 4), answering to the fourth in the dog, has a smaller proportional anterior lobe, and a larger posterior talon, which is usually notched; thereby approaching the form of the permanent lower sectorial tooth in the *Mustelidæ*.

When the premolars and the molars are below their typical number, the absent teeth are missing from the fore-part of the premolar series and from the back-part of the molar series. The most constant teeth are the fourth premolar and the first true molar; and these being known by their order and mode of development, the homologies of the remaining molars and premolars are determined by counting the molars from before backwards, *e. g.*, "one," "two," "three;" and the premolars from behind forwards, "four," "three," "two," "one."

Examples of the typical diphyodont dentition are exceptions in the actual creation; but it was the rule in the earlier forms of placental Mammalia, whether the teeth were modified for animal or vegetable food.

Not only the *Hyænodon* (fig. 113) and *Amphicyon* (fig. 114), but the *Dichodon* (fig. 118), *Anoplotherium*, *Palæotherium*, *Chæropotamus*,[1] *Anthracotherium*,[2] *Hyopotamus*,[3] *Hyracotherium*,[4] and other ancient (eocene and miocene) tertiary Mammalian genera presented the forty-four teeth, in number and kind according to that which is here propounded as the typical or normal dentition of the placental Mammalia.[5] When the clue is afforded, by the observed development and succession of the teeth, to their homologies, it infallibly conducts us to the true knowledge of the nature both of the teeth which are retained, and of those which are wanting to complete the typical number. We have availed ourselves of this in deciphering the much modified dentition of the genus *Felis;* and the same clue will guide us to the knowledge of the precise homologies of the teeth in our own species.

The discovery by the great poet Göethe of the limits of the premaxillary bone in Man leads to the determination of the incisors, which are reduced to two on each side of both jaws; the contiguous tooth shows by its shape as well as position that it is the canine, and the characters of size and shape have also served to divide the remaining five teeth in each lateral series into two bicuspids and three molars. In this instance the secondary characters conform with the essential ones. But since we have seen of how little value shape or size are, in the order *Carnivora*, in the determination of the exact homologies of the teeth, it is satisfactory to know that the more constant and important character of development gives the requisite certitude as to the nature of the so-called bicuspids in the human subject. In fig. 100, the condition of the teeth is shown in the jaws of a child of about six years of age. The two incisors on each side (*d i*) are followed by a canine (*c*), and this by three teeth having crowns resembling those of the three molar teeth of the adult. In fact, the last of the three is the first of the permanent molars; it has pushed through the gum, like the two molars which are in advance of it, without displacing any previous tooth, and the substance of the jaw contains no germ of any tooth destined to displace it; it is therefore, by this character of its development, a true molar, and the germs of the permanent teeth, which are exposed in the substance of the jaw between the diverging fangs of the molars (*d* 3 and *d* 4), prove them to be temporary, destined to be replaced, and prove also that the teeth about to displace them are premolars. According, therefore, to the rule previously laid down, we count the permanent molar in place the first of its series (*m* 1), and the adjoining premolar as the last of its series, and consequently the fourth of the typical dentition (*p* 4).

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We are thus enabled, with the same scientific certainty as that whereby we recognise in the middle toe of our foot the homologue of that great digit which forms the whole foot, and is encased by the hoof, in the horse, to point to *p* 4, or the second bicuspid in the upper jaw, and to *m* 1, or the first molar in the lower jaw, of man (fig. 145, I.), as the homologues of the great carnassial teeth of the lion (*p* 4, *m* 1, fig. 145, V.) We also conclude that the teeth which are wanting in man to complete the typical molar series, are the first and second premolars, the homologues of those marked *p* 1 and *p* 2 in the bear (fig. 145, II.) The characteristic shortening of the maxillary bones required this diminution of the number of their teeth, as well as of their size, and of the canines more especially; and the still greater curtailment of the premaxillary bone is attended with a diminished number and an altered position of the incisors. One sees, indeed, in the carnivorous series, that a corresponding decrease in the number of the premolars is concomitant with the shortening of the jaws. Already in the *Mustelidæ* (fig. 145, IV.), the first premolar below is abrogated; in *Felis* also above, with the further loss of the second premolar in the lower jaw; the true molars being correspondingly reduced in these strictly flesh-eating animals, but taken away from the back part of their series.

The homologous teeth being thus determinable, they may be severally signified by a symbol as well as by a name. The incisors, *e. g.*, are represented in the present Essay (See figs. 20 and 118) by their initial letter *i*, and individually by an added number, *i* 1, *i* 2, and *i* 3; the canines by the letter *c*; the premolars by the letter *p*; and the molars by the letter *m*; these also being differentiated by added numerals. Thus, the number of these

[1] *History of British Fossil Mammalia*, p. 416, fig. 164.
[2] Jobert, *Annales des Sciences*, t. xvii. p. 139.
[3] *Quarterly Journal of the Geological Society*, May 1848, p. 103, pl. viii.
[4] *Geological Transactions*, 2d series, vol. vi. p. 203.
[5] Thirty-eight instances are cited in the writer's memoir on "Pliolophus," *Quarterly Journal of the Geological Society*, May 1857. The seeming exception afforded by the oolitic *Plagiaulax*, on which much stress is laid by Lyell (Supplement to *Manual of Geology*, p. 21), bears upon the generalisation with about the same value as the abnormal dentition of *Proteles* does upon the generalised dental formula of the genus *Canis*. It is objected that "we ought, in every great amily of the Mammalia, to find evidence of closer adherence to the archetype the farther we recede in time" (*ib.*, p. 22). And the *Plagiaulax* is cited as evidence to the contrary. But the force of the argument really lies in the suppression of the fact, that all the other known instances of the same great Marsupial family, from oolitic strata, do give evidence of such closer adherence to archetype. The type of the Diphyodont dentition is a modification of the wider Vertebrate type of dentition; and the great majority of known oolitic Mammals exhibit that greater degree of vegetative repetition of teeth (as in fig. 74), which the theory, rightly understood, would have anticipated.

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teeth, on each side of both jaws, in any given species, Man, *e. g.*, may be expressed by the following brief formula:—

$$i\frac{2\,2}{2\,2};\ c\frac{1.1}{1.1};\ p\frac{2.2}{2.2};\ m\frac{3.3}{3.3} = 32;$$

and the homologies of the individual teeth, in relation to the typical formula, may be signified by *i* 1, *i* 2; *c*; *p* 3, *p* 4; *m* 1, *m* 2, *m* 3; the suppressed teeth being *i* 3, *p* 1, and *p* 2.

If we were desirous of further testing the soundness of the foregoing conclusions as to the nature of the teeth absent in the reduced dental formula of man, we ought to trace the mode in which the type is progressively resumed in descending from man through the order most nearly allied to our own.

Through a considerable part of the Quadrumanous series, *e. g.*, in all the Old World genera above the Lemurs, the same number and kinds of teeth are present as in man, the first deviation being the disproportionate size of the canines and the concomitant break or "diastema" in the dental series for the reception of their crowns when the mouth is shut. This is manifested in both the Chimpanzees and Orangs, together with the sexual difference in the proportions of the canine teeth. Then comes the added premolar in the New World Monkeys, and the further additions in lower quadrupeds, until in the Hog genus we see the old primitive type of Diphyodont dentition resumed or retained.

The typical dentition is departed from in the existing Hippopotamus by the early loss of *p* 1, and the reduction of the incisors to $\frac{2}{2}:\frac{2}{2}$ in both jaws; in the extinct Hippopotamus of India, *p* 1 was longer retained, and the incisors were in normal number $\frac{3}{3}:\frac{3}{3}$; whence the term *Hexaprotodon* proposed for this interesting restoration by its discoverers, Cautley and Falconer.

The existing even-toed or artiodactyle *Ungulata* superadd the characters of simplified form and diminished size to the more important and constant one of vertical succession in their premolars.[1] These teeth in the Ruminants, *e. g.* (fig. 145, VII., *Moschus*, *p* 2, 3, 4,), represent only the moiety of the true molars, or one of the two semi-cylindrical lobes of which those teeth consist, with, at most, a rudiment of the second lobe, as Cuvier very accurately describes, and F. Cuvier figures in pl. 94 of his useful work, *Dents des Mammifères*. An analogous morphological character of the premolars will be found to distinguish them in the dentition of the genus *Sus* (fig. 20), in the Hippopotamus, and in the *Phacochœrus* (fig. 124), where the premolar series is greatly reduced in number: yet this instance of a natural affinity manifested in so many other parts of the organization of the artiodactyle genera has been overlooked in F. Cuvier's work above cited, although it is expressly designed to show how such zoological relations are illustrated by the teeth. Confiding in the accuracy of the Baron Cuvier's division of the hoofed quadrupeds into "Pachyderms" and "Ruminants," M. F. Cuvier separates the non-ruminant artiodactyles from the ruminant genera of the same natural division, by interposing the Tapir, Hyrax, Rhinoceros, and Elephant; whilst the Horse, which, in the size and complexity of its premolars, as well as in many other characters, agrees closely with the other perissodactyle Ungulates, is placed in close juxtaposition with the Ruminants.

Most of the deciduous teeth of the Ruminants resemble in form the true molars; the last, *e. g.* (fig. 121, *d* 4), has three lobes in the lower jaw, like the last true molar (*m* 3).

Sufficient, it is hoped, has been adduced to prove that the molar series of the Diphyodonts is naturally divisible into only two groups, premolars and molars; that the typical number of these is $\frac{4}{4}:\frac{4}{4}$, $\frac{3}{3}:\frac{3}{3}$; and that each individual tooth may be determined and symbolised throughout the series, as is shown in the instances under cut 145. If anything were wanting to prove the artificial character of a threefold division of these teeth, and the futility of any other classification than that founded upon development, it would be afforded by the attempt to determine the homologous teeth, which is exemplified by the dotted line which traverses the series, and which crosses the teeth distinguished by the name "principales" in the great "*Ostéographie and Odontographie*" of De Blainville.

This author abandons the classification of the molar series adopted by the Cuviers, without assigning his objections to it, and proposes another, in which he divides the series into "avant-molaires, principales, and arrière-molaires;" he exemplifies this division by the human dentition, in which the five grinders on each side of both jaws are formulised as "two avant-molaires, one principale, and two arrière-molaires."[2]

With regard to the characters of these kinds of teeth, the avant-molaires are "simple or complex," the principale is "trenchant," and the arrière-molaires are "tuberculous." But as shape is not a constant character, especially in the "principale," the author proposes another from its position, describing it as "being implanted below the root of the zygomatic process of the maxillary bone" in the upper jaw; and stating that the tooth which opposes it below, and is in advance of it, is the lower "principale."

In defining the dentition of the genus *Felis*, M. de Blainville accordingly assigns one "avant-molaire," one "principale," and two "arrière-molaires" in the upper jaw; and one "avant-molaire," one "principale," and one "arrière-molaire" in the lower jaw.[3] In another part of the same work, he, however, proposes another formula, viz., two "avant-molaires," one "principale," and one "arrière-molaire" above; one "avant-molaire," one "principale," and one "arrière-molaire" below; but, taking either of these determinations, or the dental formulæ which he assigns to other carnivorous genera, and comparing them with his formula of the molar series in the Quadrumana and Man, we find that a tooth which displaces and succeeds a milk-tooth in one species is made the homologue of a tooth, which, in Man and Quadrumana, rises above the gum without displacing any predecessor; in other words, the "principale" is a premolar in certain genera, and a true molar in other genera. Reference may be made to the concluding pages of the chapter on the teeth of the Carnivora in the writer's *Odontography*, p. 514, for further proofs that a "molaire principale" does not exist in nature; that the characters by which it is defined by M. de Blainville are artificial; and that they fail in their application to determine the teeth in the series of placental Mammalia with deciduous and permanent teeth.

In the series of figures under cut 145, the line, "*Cuvier*," traverses the tooth or its homologue, from Man to the Ruminant, which Cuvier distinguished as the "molaire carnassière;" the other line traverses that tooth which M. de Blainville distinguishes as the "molaire principale;" the letters and numbers symbolise the teeth, and indicate their individual homologies, and the binary division of the molar series, which it has been one object of the present Essay to illustrate. To show how these symbols may be applied to the exposition of facts in the

[1] See the writer's "Remarks on the Classification of the Hoofed Quadrupeds," in *Quarterly Journal of the Geological Society*, May 1848. The older Eocene genera, *e. g.*, *Lophiodon* and *Pliolophus*, manifest a minor departure from type in a less changed form of one or two of the hinder premolars.

[2] *Ostéographie*, tom. i, p. 43.

[3] *Ostéographie*, p. 43.

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comparative anatomy of the teeth, the difficult homology of the proboscidian dentition, and the complex and intricate subject of the succession of the teeth in the kangaroo, will be finally selected.

With regard to the homologies of the complex molars of the proboscidian quadrupeds, a species of insight which may come to be deemed, in the course of anatomical science, as of equal import to the knowledge of the formative process of parts, it may be admitted that the mere fact of the marked and disproportionate increase of size of the first of the three last molars (fig. 139, *m* 1) over its predecessor (*d* 4), the last of the first three that are developed, seems to be but a feeble support to the analogical evidence on which chiefly the three last molars of the elephant are here classed in a category distinct from that of their smaller predecessors. But the value of such indication and analogy will begin to be apparent when we examine the condition of dental development in the primeval forms of Proboscidians. It has already been shewn that the typical character of the Diphyodont dentition was more closely and generally adhered to in the genera that existed in the old tertiary periods in geology than in their actual successors; it became, of course, highly interesting to inquire whether the Miocene Mastodons, the earliest of the great proboscidian quadrupeds of which we have any cognizance, manifested any analogous closer adhesion to type than their elephantine successors, and whether they would afford any actual proof of the true deciduous nature of the first, second, or third molars, by the development of a vertical successor or premolar. Cuvier first ascertained the fact, though without appreciating its full significance, in a specimen of the upper jaw of the *Mastodon angustidens* from Dax, in which the second six-lobed deciduous molar was displaced by a four-lobed or quadricuspid premolar developed above it, and succeeding it vertically. The same important fact was subsequently confirmed by Dr Kaup, in observations of the *Mastodon angustidens* (his *Mast. longirostris*) of the *Miocene* of Eppelsheim.

This satisfactorily proves the true deciduous character of the first and second molars (fig. 139, *d* 2 and 3); and, that the third molar in the order of appearance (*d* 4) is also one (the last) of the deciduous series, is indicated, both by the contrasted superiority of size of the tooth (*m* 1), and the more direct evidence which a comparison with the dentition of the wart-hog (fig. 124) affords, that *m* 1, fig. 139, is the first of the true molars. The great extent and activity of the processes of dental development required for the preparation of the large and complex true molar teeth, would seem to exhaust the power in Proboscidians, which, in ordinary Pachyderms, is expended in developing the vertical successors of the deciduous teeth. In the miocene Mastodon above cited, this normal exercise of the reproductive force was not, however, wholly exhausted; and one premolar (fig. 139, *p* 3), of more simple form than its deciduous predecessor, was developed on each side of both jaws; but even this trace of adherence to the archetypal dentition is lost in the more modified Proboscidians of the present day. Another and interesting mark of adhesion to the archetype was shown by the development of two incisors in the lower jaw in the young of some of the Mastodons, by the retention and development of one of these inferior tusks in the male of the *Mastodon giganteus* of North America, and by the retention of both in the European *Mastodon angustidens* (fig. 140). No trace of these inferior homotypes of the premaxillary tusks have been detected in the fœtus or young of the existing elephants. In the gigantic *Dinotherium*, the upper incisors were suppressed, and the lower incisors were developed into huge tusks, which curved down from the symphysis of the massive lower jaw.

The chief modifications of the marsupial dentition have already been described and illustrated. The observed phenomena of the development and change of the teeth led to the generalisation that the marsupial differed from the placental Diphyodont mammals in having four true molars, *i. e.*, $m.\frac{4.4}{4.4}$ instead of $m.\frac{3.3}{3.3}$; and also that they differed in having only three premolars, *i. e.* $p.\frac{3.3}{3.3}$ instead of $p.\frac{4.4}{4.4}$; the typical number of the grinding series, $\frac{7.7}{7.7}$, being the same. Since, however, there is reason to conclude that *m* 1 in the placental series, as, *e. g.*, figs. 17 and 124, is a continuation of the deciduous series of molars, which might be symbolised as *d* 5, and only becomes a permanent molar because there is no premolar developed above it, so we may regard the tooth marked *m* 1 in figs. 75, 76 and 78 as being an antecedent tooth of the deciduous series, rendered permanent by a like reason, the suppression, viz. of *p* 4. In other words, that *m* 1 in fig. 75 is the homologue of *d* 4 in fig. 17, and that the true homologue of *p.* 4 is not developed in the *Marsupialia*.

The homologues of the teeth of the Kangaroo are illustrated in fig. 146, according to this idea of them.

The permanent dental formula of both the *Macropodidæ* and *Hypsiprymnidæ*, according to the usual view, as given at p. 449, is—

$$i\frac{3.3}{1.1};\ c\frac{1.1}{0.0};\ p\frac{1.1}{1.1};\ m\frac{4.4}{4.4}=30.$$

According to the real state of things it is—

$$i\frac{3.3}{1.1};\ c\frac{1.1}{0.0};\ p\frac{1.1}{1.1};\ d\frac{1.1}{1.1};\ m\frac{3.3}{3.3}=30.$$

The canines, which are confined to the upper jaw, are small or minute when retained; and disappear after being represented "en germe" in most of the true Kangaroos.

The deciduous dentition of the great Kangaroo (*Macropus major*) is—

$$i\frac{3.3}{1.1};\ c\frac{1.1}{0.0};\ m\frac{2.2}{2.2}=18.$$

The canines are rudimental, and are absorbed rather than shed. The deciduous incisors are shed before the young animal finally quits the pouch; when this takes place, the dentition is—

$$i\frac{1.1}{1.1};\ d\,m\frac{2.2}{2.2}=12;$$

the upper incisors being *i* 1, the molars *d* 2 and *d* 3 of the typical dentition. This stage is exemplified in the lower jaw at A (fig. 146). The next stage shows the acquisition of *i* 2 in the upper jaw, and *d* 4 in both jaws, and the formula is—

$$i\frac{2.2}{1.1};\ d\,m\frac{3.3}{3.3}=18\ \text{(B, fig. 146)}.$$

At one year old, the dentition is—

$$i\frac{3.3}{1.1};\ d\,m\frac{3.3}{3.3};\ m\frac{1.1}{1.1}=24;$$

the additional teeth being *i* 3 and *m* 1 (C, fig. 146), in which the demonstration of the true deciduous character of *d* 2 and *d* 3 is shown by the germ of their vertical successor *p* 3, which is exposed in the substance of the jaw. The next stage is the shedding of *d* 2, and the acquisition of *m* 2 (D, fig. 146). Then *d* 3 is shed by the ascent of *p* 3 into its place (E, fig. 146). Afterwards *m* 3 is acquired; and in the *Macropus gigas*, *p* 3, simultaneously pushed out (F, fig. 146).

Thus, four individuals of this species may be found to have the same number of molars, *i. e.* $\frac{4.4}{4.4}$; two of these individuals may seem, on a cursory comparison, to have them of the same shape, *e. g.*, as in C and E, fig. 146, or as in D and F. In fact, to determine the identity or difference in such instances, it requires that the substance of

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the jaws be examined, to see if the germs of successional teeth be present, as at *p* 3, C and D, or at *m* 3, E. The result of such examination may be to show that not one of the four Kangaroos with the $m\frac{4\,4}{4\,4}$ had the same or homologous teeth. The four grinders, *e. g.* may be—

d 2, *d* 3, *d* 4, *m* 1; as in C; or
d 3, *d* 4, *m* 1, *m* 2; as in D; or
p 3, *d* 4, *m* 1, *m* 2; as in E; or
d 4, *m* 1, *m* 2, and *m* 3; as in F.

The changes, however, do not end here. As age advances, *d* 4 is shed, and the molar series is reduced numerically to the condition of B; but, instead of *d* 4, *d* 3, and *d* 2, it consists of *m* 1, *m* 2, *m* 3.

Finally, *m* 1 is shed, and the dentition is reduced to the same numerical state as at A; the teeth, however, being *m* 2 and *m* 3. The order here described is not precisely that which is followed in some of the smaller species of Kangaroo. In *Macropus Benettii*, *e. g.* the acquisition of *m* 3 is not accompanied by the displacement of *p* 3; and a molar series of $\frac{5}{5}:\frac{5}{5}$ is long retained.

These symbols, it is hoped, are so plain and simple as to have formed no obstacle to the full and easy comprehension of the facts explained by means of them. If these facts, in the manifold diversities of Mammalian dentition, were to be described in the ordinary way, by means of verbal phrases or definitions of the teeth, *e. g.*, the second deciduous molar representing the fourth in the typical dentition, instead of *d* 4, and so on, the description of dental development would continue to occupy much unnecessary space, and would levy such a tax upon the attention and memory as must tend to enfeeble the judgment and impair the power of seizing and appreciating the results of the comparison.

Each year's experience has strengthened the writer's conviction that the rapid and successful progress of the knowledge of animal structures, and of the generalizations deducible therefrom, will be mainly influenced by the determination of the homology of parts and organs, and by the concomitant power of condensing the propositions relating to them, and of attaching to them signs or symbols equivalent to their single substantive names. In the writer's work on the *Archetype of the Skeleton*, he has denoted most of the bones by simple numerals. The symbols of the teeth are fewer in number, are easily understood and remembered, and, if generally adopted, might take the place of names. They would then render unnecessary the endless repetition of the verbal definitions of the parts, harmonize conflicting synonyms, serve as a universal language, and at the same time express the expositor's meaning in the fewest and clearest terms. The entomologist has long found the advantage of such signs as ☿ and ♀, in reference to the sexes of insects, and the like; and it is hoped that the time is now come when the anatomist may avail himself of this powerful instrument of thought, instruction, and discovery, from which the chemist, the astronomer, and the geometrician have obtained such important results.

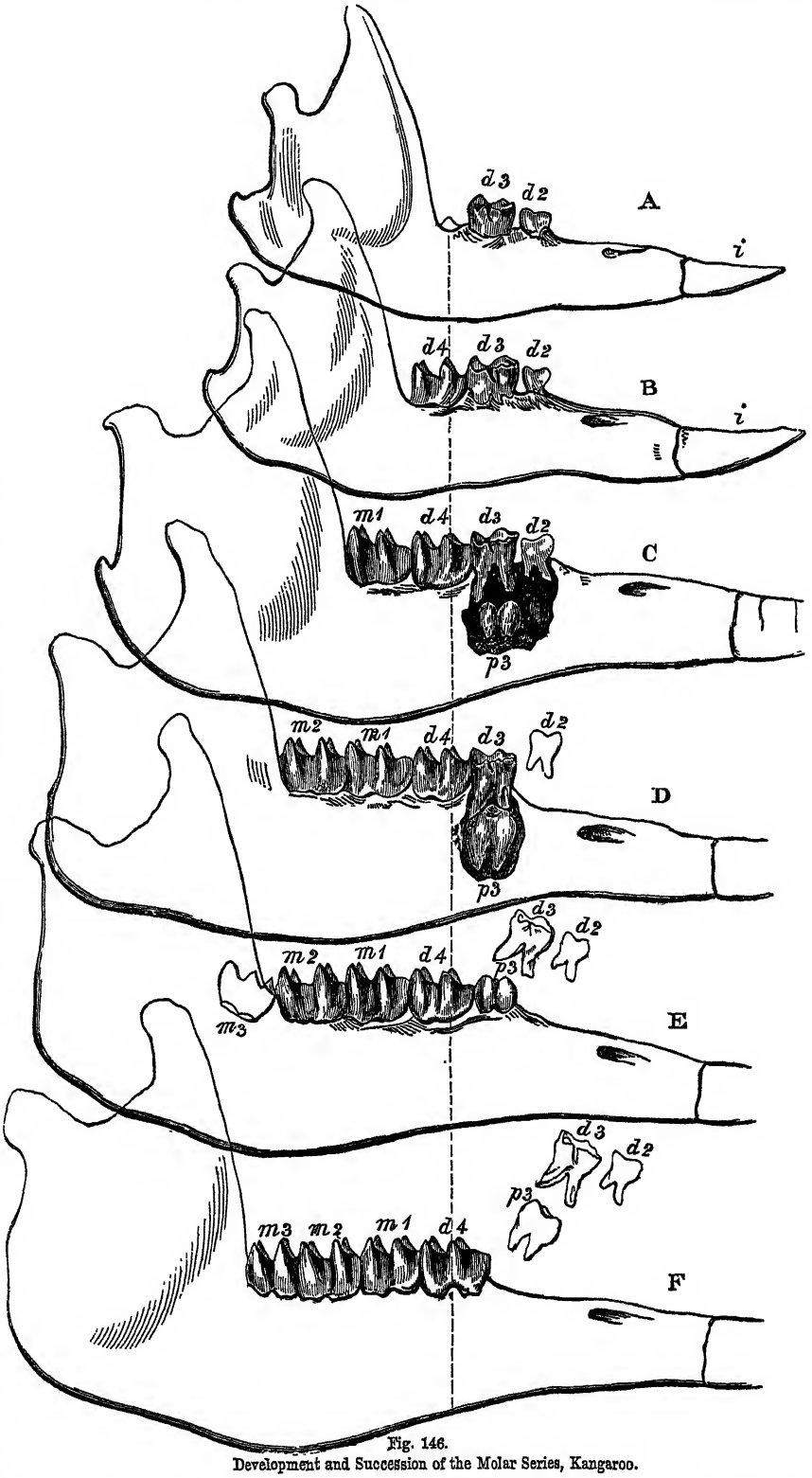

Fig. 146.
Development and Succession of the Molar Series, Kangaroo.

(R. O.)

ODRYSÆ, an important tribe of Thrace, occupied a territory whose limits were different at different times, but whose central part was on the banks of the Artiscus and in the neighbourhood of the Hebrus. They seem to have been a colony of that horde of barbarians that came pouring into Thrace from the north after the Trojan war. They were an important people from the first period of their settlement. Their name frequently occurs in legendary history. Thamyris, the ancient bard, is said to have been one of their tribe, and Orpheus is represented to have been their king. At the date of their introduction into authentic history, during the invasion of Scythia by Darius Hystaspis, their native mountains protected their independence against the Persians; and the fine breed of horses which they pastured on the plains of the Hebrus supplied their armies with a large and efficient squadron of cavalry. In the latter half of the fifth century B.C. they had extended their territory northward to the Danube, westward to Abdera, and eastward to the Euxine Sea; and their annual revenue had risen to be equal to the sum of 800 talents. The prosperity of the Odrysæ, however, had now reached its zenith, and began to decline. A disputed succession divided them into factions, and made them an easy prey for their ambitious neighbours. In 357 B.C., after a course of various fortune, the Athenians wrested from them the Thracian Chersonese; and in 343 B.C., after a war of nine or ten years, Philip II. of Macedon reduced them to the state of tributaries, and began to plant Philippopolis and other colonies in the very heart of the country. Yet the spirit of independence among the Odrysæ soon began to revive, and even before the death of Alexander the Great they had raised the standard of rebellion. On the accession of Lysimachus to the sovereignty of Thrace they commenced a struggle for liberty, which continued with various intervals till the fall of the Macedonian kingdom. The Odrysæ then became the auxiliaries of the Romans, and were employed in subjecting the other Thracian tribes to the dominion of Rome. Yet they retained a form of independence, and were treated like allies rather than tributaries. Augustus allowed them still to be governed by native sovereigns, even though their king Sadales, in 42 B.C., had bequeathed his kingdom to the Romans; Crassus bestowed upon them parts of the territory of the Bessi; and in course of time Rome had placed the whole of Thrace under their control. Yet in the time of Tiberius they began a series of rebellions, which resulted in the abolition of their independence, and the reduction of their territory into the form of a Roman province, during the reign of Vespasian.

ŒCOLAMPADIUS, the Græcized name of *Johann Hausschein*, one of the most eminent of the Reformers. He was descended by his mother's side from a Swiss family, and was born at Weinsberg in Franconia in 1482. His father, a wealthy merchant, at first intended him for trade, and afterwards sent him to Bologna to learn jurisprudence. But the timid youth, averse to the turmoil of business and fond of letters, soon entered upon the peaceful and studious life of an ecclesiastic. He studied divinity at Heidelberg, and Greek and Hebrew at Stuttgardt; in 1516 he was preaching at Basle, and assisting his friend Erasmus in publishing *Annotations on the New Testament;* and in 1520 he retired into the monastery of Altenmünster, near Augsburg. Yet underneath this love of literary ease there was a strong sincerity of heart, which would not suffer him to remain undecided in the midst of the controversies of those reforming days. Before two years had passed, his attacks upon the creed of the Romish Church had brought him into danger: he escaped immediately from the convent, and took refuge in the castle of Ebernburg; and in 1524 he undertook the duties of a preacher and a theological professor at Basle, with the avowed intention of teaching nothing but what was consistent with the Scriptures. From this period Œcolampadius was a learned, tolerant, yet decided advocate of the opinions of the Reformed in Switzerland. In a short time his elegant and powerful eloquence had overcome all opposition in Basle; and a thorough reformation of the church in that town was going rapidly on under his superintendence. He then went to the assistance of Zwingle in the controversy with Luther regarding the real presence in the Eucharist. A treatise, entitled *De vero intellectu verborum Domini "Hoc est Corpus Meum,"* was published by him in 1525; this was followed, as the controversy proceeded, by several letters and pamphlets; and in the celebrated discussion in 1529 at Marburg between the champions of the two parties, he entered the lists against the great German Reformer. He was still busily engaged both with tongue and pen in refuting the Lutherans, when death closed his career, in December 1531.

The principal works of Œcolampadius are—*In Librum Job Exegemata—In Danielem Prophetam Libri Duo*, fol. 1553; and *Commentarii Omnes in Libros Prophetarum*, in 2 vols. fol., 1558. His Life, written in Latin by Capito, and published in 4to, 1536, was translated into English, and printed along with those of Zwingle and Luther, by Henry Bennet Callesian, 8vo, London, 1561. There is also a Life, in German, by Herzog, in 2 vols., 1843.

ŒCUMENICAL COUNCILS. See COUNCIL.

OEDENBURG (Hung. *Sopron* or *Soprony;* anc. *Sempronium* or *Sopronium*), a town of Hungary, capital of a county of the same name, stands on the Ilkva, not far from the Neusiedlersee, 36 miles S.S.E. of Vienna. It is well built, and has the appearance of a quiet Austrian country town, with little of the Hungarian character about it. The watch-tower, which is all that remains of the old fortifications, is said to be the loftiest in Hungary. Some of the Roman Catholic churches are fine Gothic edifices; and there are also a Protestant church, a Dominican convent, a Ursuline nunnery, Roman Catholic and Protestant schools, orphan hospital, and theatre. Manufactures of woollen, linen, and cotton fabrics, potash, hardware, &c., are carried on; and the town has also sugar refineries and potteries. Some trade is carried on in these articles, as well as in the produce of the country; and large markets for cattle are held here, at which about 40,000 oxen and 160,000 pigs are sold annually. Many Roman antiquities have been found in the town. The inhabitants are mostly Germans, and about half of them are Protestants. Pop. (1851) 16,274.

The county of Oedenburg, which is bounded N.E. by Wiesselburg, E. by Raab, S. by Eisenburg, W. and N. by the archduchy of Austria, has an area of 1272 square miles. It is occupied on the W. by low branches of the Styrian Alps, while towards the E. it is quite flat. Nearly the whole of Neusiedlersee is in this county, and it receives the most of the rivers. The soil is generally fertile, though swampy in some parts, and yields large crops of corn, flax, wine, and fruits. Live stock are reared to a considerable extent, and abundance of fish is obtained from the lake. Pop. 207,800.

ŒDIPUS, an ancient Grecian king, whose tragical sorrows were a favourite subject of the classical poets, was the son of Laius and Jocasta, the King and Queen of Thebes. The following is the ordinary account of the cruel destiny of his life. King Laius had been warned beforehand by an oracle that he should be slain by his son. Accordingly, no sooner was the infant born, than with his feet bored and bound together, he was carried away and exposed on Mount Cithæron. A shepherd chancing to pass that way, took him up and conveyed him to Polybus, the tyrant of Corinth. This king, being childless, adopted the infant, and seeing his little feet swollen, called him *Œdipus*. Years passed by; and the foundling was growing up at the Corinthian court a young man, and the reputed son of Polybus, when one

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day he heard his supposed parentage tauntingly questioned. This threw him into the torture of uncertainty, and hurried him away to consult the oracle of Delphi. The oracle would give no other response than the prediction that he should slay his father and marry his mother. Shuddering under the prophecy, Œdipus resolved to return no more to Corinth, and, led blindly on by Destiny, he bent his steps towards Thebes. On a narrow part of the road between Delphi and Daulis, a menial driving an elderly personage in a chariot called to him saucily to get out of the way. The insult was resented; a scuffle ensued; and the young traveller slew his two opponents. The elderly personage was Laius; and thus part of the horrible prediction had been fulfilled. Unconscious of what he had done, Œdipus held on his way; and arriving at Thebes, found the neighbourhood in a terrible dilemma. The Sphinx, settled upon a rock, was exacting, on pain of death, from all who passed by an answer to a riddle; every one in turn was failing in the attempt to give a solution; and the population was fast wasting away before the clutches of the monster. At this juncture Œdipus solved the fatal enigma, and the Sphinx fell lifeless from her lofty seat. The hand of Queen Jocasta was bestowed as a reward upon the deliverer of the people; and thus the fulfilment of the predicted destiny was completed. Several years, however, passed before it was known. At length a plague fell upon the Thebans; the oracle declared that the calamity could only be stopped by the discovery of the murderer of Laius; the seer Tiresias made this discovery; and the revolting secret burst disastrously upon the royal family. Jocasta hung herself; Œdipus tore out his eyes. In course of time he wandered forth, led by his daughter Antigone, and after much travel, found himself near Colonus in Attica. Entering the unapproachable grove of the Furies, he remained there under the protection of these dread goddesses till his death. The history of Œdipus furnished the subject of several ancient tragic poems. The *Œdipus Tyrannus* and the *Œdipus Colonus* by Sophocles, and the *Œdipus* by Seneca, are still extant.

OEHLENSCHLAGER, Adam Gottlob, the greatest poet and dramatist of Denmark, was born at Westerbrö, a suburb of Copenhagen, on the 14th of November 1779. He was named after his father's patron, Count Adam Gottlob Moltke, who had secured for the elder Oehlenschläger the place of organist, and afterwards that of steward of the royal chateau of Fredericksborg. This palace, distant about two miles from Copenhagen, and built, it is said, after the design of Inigo Jones, was a favourite resort of the court in summer, but in winter was left to the solitary occupation of the poet's parents, two watchmen, and a couple of dogs. Here the boy grew up; and he was fond of recording in later years the delight with which he used to traverse the stately but deserted apartments, feeding his childish eye with gazing on the portraits of heroes and kings, and imagining for himself a brilliant future of fortune and fame. Here he acquired such rudimentary knowledge as the dame's school and the parish clerk could furnish, and he was allowed to read whatever came in his way, or could be found to his taste in a circulating library of the capital, to which he was permitted by his father to make exploring expeditions on fine days. His reading lay chiefly in romances, old and new. *Robinson Crusoe* and *Tom Jones* shared his favour with the *Arabian Nights* and *Siegfried the Dragon-Slayer;* and he knew the Comedies of Holberg, the German Molière, almost by heart. In boyhood, as in after life, he felt the beauties of nature deeply, and was quick in the perception of character. The beautiful suburb in which he lived a free and rambling life gratified his sense of natural beauty; and even in the narrow and homely circle of his father's friends he found scope for the exercise of his faculty of observation. The power of improvisation, and the impulse to convey his own ideas and impressions to others, so often developed in boyhood and lost in after years, showed itself early in him; and before he was twelve years of age he was overheard by the clergyman preaching in the chapel to an imaginary audience with so much effect, that his unexpected auditor urged his parents to educate him for the church. To give him an education in the capital was, however, beyond his father's humble means. Fortunately for his future career, his talents attracted the notice of Edward Storm, the Norwegian poet, who procured his admission as a free scholar into the School for Posterity in Copenhagen, of which Storm was superintendent. Here the same activity of mind continued to be shown; but Latin and history suffered not a little beside the stronger attractions of poetry and the drama. Oehlenschläger's mind was not one to pursue any study with method, or to follow it into its depths. His curiosity and thirst for knowledge, always active, was quickly satisfied, and as quickly started off in search of some new object. As his boyhood advanced, the dramatic faculty became more developed. The characters he imagined, he was irresistibly compelled to embody and to put into action. Thus he used to write little pieces to be acted by himself and his playfellows, among whom he soon became a favourite and a leader. His facility of composition was even then remarkable. "My dear boy," Storm said to him once with quiet irony, "you are a greater poet than Molière. It used to be thought a feat in him to write and bring out a piece in eight days; you dash it off with ease in one." Storm, with whom he was a favourite, looked after his studies for three of the four years he remained at the Posterity School, when death deprived him of the poet's kind and thoughtful friendship. Oehlenschläger took a fair place among his fellow-students; and, despite his desultory habits and imaginative pursuits, he acquired during this period a fair knowledge of history, geography, and his mother tongue; he was well up in geometry and trigonometry, had mastered German, knew something of French, and had gained a superficial knowledge of some of the sciences. At the age of sixteen Oehlenschläger was confirmed, and left the school; and now the question arose, to what he was to turn? His father's scanty means made it important that the boy should be speedily put in the way of earning his own livelihood. Commerce was talked of; but a merchant without money was, as his mother said, like a violin without strings. Oehlenschläger, besides, knew nothing of English, then, as now, the great language of trade; and arithmetic had always been his stumbling-block. A vacancy, however, was heard of in the counting-house of a friend at Christianshafen, and thither Oehlenschläger, with a heavy heart, went with his father. To his infinite satisfaction they found that the young man whose place he was to fill had resumed his duties, and they had to return as they went. On the way back Oehlenschläger persuaded his father, whose disposition was easy to a fault, to allow him to prosecute at home the studies necessary to enable him to take his degree in arts. To these he applied himself for some time with zeal, taking lessons in Greek and Latin from the tutor of the sons of the gardener at Fredericksborg; but his progress in these severer studies was not great. The Muses continued to assert their mastery over him, and his scanty pocket-money was expended upon plays and visits to the theatre. Despairing of success in any other career, he determined to go upon the stage, for which he was in some measure prepared by his practice in the plays which he had been in the habit of performing with his companions. Having with some difficulty obtained his parents' consent to this step, and secured from the necessary authority an admission to the court theatre at Copenhagen, he made his appearance, after a course of preliminary study under the direction of Rosing, then the leading actor there. He continued on the Copenhagen stage for nearly two years; but his success was simply respectable, and

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not such as to reconcile him to the difficulties and anxieties of a profession for which he had manifestly no peculiar vocation. His office was to write plays, not to act them. A variety of little circumstances combined to make his position in the theatre irksome. Rosing alone seems to have entertained hopes of him as an actor. This was not enough for Oehlenschläger, and he threw up his engagement, after having remained on the stage just long enough to learn something of the technical requirements of the art for which he was afterwards to minister such admirable materials. About this time, too, he had made the acquaintance of the brothers Oersted, one of whom afterwards married his sister. Their habits of methodical and profound study impressed him deeply. He had seen nothing like it before, and, contrasting their attainments with his own, he was stimulated to retrieve, if possible, the time which he had lost. To this he was encouraged by these gifted brothers; and, under the guidance of Anders Sandöe Oersted, he devoted himself for a time with ardour to the study of jurisprudence, and passed the preliminary examinations with credit. Oehlenschläger was still only nineteen, and his poetic powers had been quickened into action by the loss of his mother, whom he loved tenderly and deeply, and by an attachment which he formed for his first and only love, Christiana Georgina Elizabeth Heger, the daughter of the Counsellor Heger. Literature soon divided his attention with the studies of law. He read much, especially in the authors of the great German school, which had recently sprung up; and his writings, both in verse and prose, began to attract attention. He associated with men of letters, and gave much attention to the study of northern antiquities, mythology, and literature. The expedition of the British fleet against Copenhagen for a time interrupted these peaceful studies. Oehlenschläger joined a corps of volunteers, and has left an amusing account of their amateur military career. This temporary distraction over, he returned with renewed activity to his former literary pursuits, and in 1803 published his first volume of poetry. Some of its contents are worthy of his subsequent fame; but it was not until the appearance of his dramatic poem of *Aladdin* in 1804 that he gave the assurance of realizing the boast with which, in a moment of enthusiasm, he had on one occasion startled and amused his companions, that he would one day rescue Danish poetry from the decay into which it had fallen since the days of Ewald. This work bears the unmistakeable impress of genius. The luxuriance of fancy, the freshness and exuberance of feeling, the variety and truth of the characters, the spontaneousness of emotion, and the pervading sense of power, reconcile the reader to its want of compression and occasional feebleness of execution. All the wealth of a lively and sensitive nature is scattered lavishly over its pages. In the composition of this work Oehlenschläger felt that nature had destined him for a poet, and not for a lawyer. His countrymen took the same view; and, through the interest of Count Schimmelman, he obtained from the Danish government a travelling pension in August 1805. With this he made a tour through Germany, where he made the acquaintance of Goethe and Wieland, and the brilliant circle whom the old Duchess Amelia had gathered around her at Weimar. At Halle he wrote his *Hakon Jarl*, his second play, in six weeks. At Goethe's suggestion he translated the *Aladdin* into German, and he dedicated his translation to that poet in lines of great beauty. He followed the same course with reference to all his principal plays, revising as he translated them, so that they frequently appear to more advantage in their German than in their Danish dress. From Weimar he went to Paris, where he wrote his *Palnatoke*, and *Azel und Walburg*, dramas unsurpassed by any of his later works. Here, too, he conceived the idea of his *Correggio*, the first and best of the long line of art-dramas in which Germany has since been prolific, although it was in Parma that this fine work fitly took a definite shape, which was afterwards perfected in Rome. After an absence of five years, Oehlenschläger returned in 1810 to Copenhagen, where he was already famous, and an enthusiastic reception awaited him. He had endowed some of the finest national legends with a noble dramatic life, and laid the foundation of a national drama of the best kind. His countrymen were proud of him, and at this early period, as through all the rest of his long life, were not sparing in their demonstrations of regard. He was appointed professor of æsthetics at the university of Copenhagen,—a position which he continued to fill with honour till nearly the close of his life. On the 10th of May 1810 he married Christiana Heger, to whom he had been so long betrothed, and whom, after the companionship of many years of uninterrupted happiness, he lived to regret. From the time of his return to Copenhagen, Oehlenschläger's life was one unbroken career of literary labour and of literary honour. He wrote much in nearly all departments of the belles lettres,—poems, dramas (serious and comic), operettas, tales, and novels. It is by his dramas, however, that posterity will know him. Besides comedies and operas, he wrote twenty-four tragedies, of which nineteen are on Scandinavian themes. These are of various and unequal merit; but all are more or less deserving of perusal, and some will rank among the first in the first class of modern dramas. Like all dramatists of the highest order, Oehlenschläger himself is not seen in the best of his works. His characters feel and speak with a spontaneousness, and truth to the situation, which make the reader forget the author in the living reality of the scene. The art to blot, however, was one which Oehlenschläger seems never to have learned. As the first impulse came, so he wrote; and his writings accordingly bear many traces of feebleness, which a more vigorous judgment would have been at pains to remove. Oehlenschläger was scarcely less esteemed in Sweden than in Denmark. In the summer of 1829 he visited that country, where he was greeted by all classes with a burst of enthusiasm such as commonly is bestowed only on conquerors or kings. He was met on the high road by a procession of students. Addresses were presented to him from all quarters. At the distribution of degrees in the ancient cathedral of Lund, Bishop Tegnér, the greatest poet of Sweden, saluted him with a panegyric in hexameters in which he was hailed as the king of the poets of the north, and placed a laurel crown upon his head amidst a storm of music and artillery. Soon afterwards he was made a knight of the North Star by the King of Sweden, and received the diploma of doctor of philosophy from the university of Lund. Ovations not less gratifying awaited him on a subsequent visit to Sweden, and also to Norway. In 1815 he received from the King of Denmark the knighthood of Dannebrog, and in 1839 he was appointed counsellor of state. Other and higher honours were subsequently conferred upon him in his own country; and from the sovereigns of Sweden, Prussia, and Belgium he received similar distinctions. A great festival was held at Copenhagen on the 14th November 1849, in honour of his seventieth birthday, on which occasion he recited a poetical address, in which he said,—

> "Although the end far distant may not be,
> There's life and sinew in the old man yet;
> To you I drink, and drain the cup with glee,
> For 'tis no funeral feast that here is set."

He was then in the full enjoyment of all his powers, and was even then busy with literary tasks. But about six weeks afterwards symptoms of a breaking up of the constitution appeared; and he died on the 20th of January 1850. About an hour and a half before his death he requested his son to read to him that part of the scene in the fifth act of his tragedy of *Socrates*, where the philosopher speaks of death.

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Oels ‖ Oeniadæ.

"It is," he said, "so unspeakably beautiful." He heard the passage read with deep emotion, "and with a smile," says the biographer, "of rapturous delight. When it was concluded, he put an end to the reading, and took leave of his family." The incident is characteristic, not, as has been said, of the poet's vanity, but of his simple faith, which regarded himself only as the medium through which an inspiration from a higher source spoke. So it was with Oehlenschläger through life. His poetry flowed from him under an inspiration as unconscious, and often as fitful, as music from the wind-swept chords of an Æolian lyre. When the mood passed, he seems to have rarely set himself to the task of rejecting what was weak or indifferent, or heightening by the touches of art what had been left imperfect in the heat of composition. Oehlenschläger's death was felt as a national loss, and his obsequies were celebrated with almost regal honours. A funeral oration was pronounced over his remains by the Bishop of Seeland in the cathedral of Copenhagen, and they were then borne to the church of Fredericksborg attended by a crowd of more than 20,000 people, or about a sixth of the entire population of the capital. The prince royal, the royal aides-de-camp, the whole diplomatic body, all the clergy, and the different guilds of arts and manufactures, swelled the train; and the coffin was borne by the youth of the public schools. Thus royally attended, the great Scandinavian bard was laid to rest in the grave of his fathers on the 26th January 1850.

Oehlenschläger was robust in body as in mind,—a burly man, with a large head, and features which beamed with intelligence and vivacity. He seemed to be rather a child of the sunny south than of the north. His complexion was tinged with ruddy bronze, his eyes were dark and brilliant, his smile full and joyous, his gestures animated and quick. His sensibilities were at all times readily moved. He enjoyed keenly, and his sympathies were wide and genial. There was to the last much of the child in him; and in the midst of their admiration his friends were often moved to smile at his harmless egotism. Rarely has a poet's life been happier, or more in harmony with his nature. Born poor, he was fortunate in the love of parents with whom he grew up in an atmosphere of simplicity, integrity, and piety. He was fortunately enabled by well-timed patronage to follow from the first the instincts of his genius. His country early recognised his claims. Placed by it in a position to pursue his literary career without anxiety, he was cheered through life by the assurance that his efforts were watched with interest, and welcomed with hearty sympathy. Rich in purse he never was; but he was rich in the love of a wife to whom he was devoted, and of children who caused him no regrets,—rich in the possession of all his powers of mind and body to the close of a long life,—rich in the love of honoured friends, and in the admiration of his country. In him genius was happily allied with goodness; and the world dealt kindly with the man whom nature had endowed with many of her choicest gifts. (T. M—N.)

OELS, a town of Prussia, in the government of Breslau, on the Oelsa, 17 miles N.N.E. of Breslau. It is fortified; and has an extensive ducal palace built in the form of a square, and containing a good library; a Roman Catholic and three Protestant churches, a synagogue, several schools, an hospital, and a theatre. Manufactures of woollen, linen, and silken stuffs are carried on here; and there are oil and other mills. Pop. 6928.

OENIADÆ (modern *Trikardho*), an important town of Acarnania in ancient Greece, was situated on the western bank of the Achelous (*Aspropotamo*), about 2 miles from the mouth of that river. Its name was probably derived from Œneus, a legendary Ætolian hero. It stood on an insulated hill, strengthened by massive walls, and surrounded on all sides by extensive morasses. These fortifications, natural and artificial, rendered the town for a considerable time a formidable and invincible foe to the Athenians. Pericles was unable to take it by siege in 454 B.C.; Phormion advanced against it in 429 B.C., but could not pass across the swamps; and it was not until 424 B.C. that it was forced by the general Demosthenes to take the Athenian side in the Peloponnesian war. This seems to have been a fatal blow to the independence of Œniadæ. In the latter half of the fourth century B.C. it was taken by the Ætolians; in 219 B.C. it passed into the hands of Philip, King of Macedonia; and in 211 B.C. it was captured by the Romans, and given once more to the Ætolians. Although the citizens were freed from the dominion of their fellow-countrymen in 189 B.C., they never recovered their former importance. From that date Œniadæ disappeared from the arena of history. Large portions of its walls still remain in excellent preservation.

Oenotria ‖ Offenbach.

OENOTRIA. See ITALY.

OERSTED, HANS CHRISTIAN. See DISSERTATION SIXTH, chap. vii., sec. 4.

OESEL, an island belonging to Russia, stretches across the mouth of the Gulf of Riga, between N. Lat. 58. and 58. 40., E. Long. 21. 40. and 23. 20. Its length from S. by W. to N. by E. is about 45 miles; average breadth, 12 miles; area, about 1200 square miles. Next to Zealand, this is the largest of the islands in the Baltic. It has steep and bold coasts, and a rocky undulating surface, watered by numerous streams. The rocks are for the most part calcareous; and the soil, though not naturally fertile, may be made productive by means of manure. A great part of the island is covered with forests, and a considerable extent of it is used as pasture ground. The climate is milder in winter than that of the adjacent mainland; but in spring and autumn severe storms frequently occur. Corn is raised in sufficient quantities to furnish an article of exportation; wheat, rye, barley, and oats being the principal crops; while hemp and flax are also cultivated. Many of the inhabitants are also employed in pastoral and piscatorial pursuits. Few manufactures are carried on. The majority of the people are Lutherans; and the chief town is Arensberg, on the S.E. coast. Œsel at one time belonged to the Teutonic knights, but was seized by the Danes at an early period, and ceded by them to Sweden in 1645. In the beginning of the eighteenth century it was taken possession of by Russia, to which power it was finally ceded in 1721 along with Livonia, of which government it forms a part. Pop. about 40,000.

OETINGER, FRIEDRICH CHRISTOPH, a mystic divine, was born in 1702 at Göppingen in Würtemberg. After finishing his education at the university of Leipsic, and occupying himself with several learned engagements, he was appointed pastor at Hirschau in 1738. It was about this time that he began to imbibe the doctrines of mysticism from the treatises of Bœhmen and others. In 1765 his edition of the works of Swedenborg, in 2 vols. 8vo, and his treatise entitled *Earthly and Heavenly Philosophy*, revealed his opinions to the public, and drew down upon him the reprehension of his ecclesiastical superiors. Yet protected by the Duke of Würtemberg, and aided by his own excellent character, he rose to a high position in the church. After passing through several grades of promotion, he was appointed prelate at Murhard, and continued there till his death in 1782.

OFANTO (anc. *Aufidus*), a river of Italy, in the Kingdom of Naples, rises in the Apennines, province of Principato Ultra, flows E.N.E., separating Capitanata from Basilicata and Bari, and falls into the Adriatic, after a course of 75 miles. On the right bank is the field of the battle of Cannæ, where the Romans were totally defeated by Hannibal, B.C. 216.

OFFENBACH, a town of Hesse-Darmstadt, province of Starkenburg, on the left banks of the Main, here crossed by a bridge of boats, 5 miles E.S.E. of Frankfort. It is well

Offenburg || Ohio.

built and partly walled; and has a ducal palace, several churches, a school, poor-houses, theatre, &c. Its manufactures are extensive, consisting of woollen, cotton, and silken fabrics; gloves, wax-cloth, leather, soap, earthenware, &c. There are no fewer than ninety-five manufacturing establishments in the town, employing 6000 hands, and producing annually about L.650,000 worth of goods. This place is also remarkable for its bookbinding, in which art it is superior to any other place in Germany. An active trade is carried on in wine and other articles. Pop. (1852) 13,087.

OFFENBURG, a town of Baden, in the circle of Mittelrhein, on a hill near the Kinzig, 42 miles S.S.W. of Karlsrühe. It has a town-house, merchants' hall, school, nunnery, hospital, &c. Manufactures of leather, glass, and other articles, and some trade, are carried on. Pop. 4010.

OFFICINAL, is the name applied to such medicines, whether simple or compound, as are required to be constantly kept in the apothecaries' shops.

OGDENSBURG, a town of the United States of North America, state of New York, on a plain at the confluence of the Oswegatchie with the St Lawrence, 200 miles N.N.W. of Albany. It is well and regularly built; and contains numerous churches, belonging to Presbyterians, Episcopalians, Methodists, Baptists, and Roman Catholics; an academy; and three banks. There are iron-foundries, machine-shops, and other manufactories. The trade of the town is considerable; and it communicates by steam-vessels with the different ports on Lake Ontario. It is also connected by railway with Boston and New York. The number of vessels that entered the port in 1852 was 830; tonnage, 347,698: that cleared, 798; tonnage, 341,188. Pop. (1853) about 6500.

OGECHEE, a river of the United States of North America, state of Georgia, flows S.E., and falls into the Atlantic by Ossabaw Sound, 20 miles S. of Savannah. Its whole length is 250 miles; and it is navigable by sloops for 30 or 40 miles.

OGILVY, JOHN, an industrious author and literary speculator, was born at Edinburgh in 1600. His father was a prisoner for debt in the King's Bench, and could give him but little education. Yet the boy had a practical ingenuity, and an ever-wakeful prudence which led him over the greatest difficulties on towards success. While supporting himself by teaching dancing to the families of the English nobility, he contrived to gratify his eager avidity for learning. In 1649 his literary accomplishments had become so considerable that he became an author by profession, and began to publish a series of metrical translations of some of the ancient classics. His Virgil appeared in that same year, his *Fables of Æsop* in 1651, his *Iliad* in 1660, and his *Odyssey* in 1665. Yet although Ogilvy had gained distinction by these publications, and although he had been appointed superintendent of the poetical part of the coronation pageantry in 1661, and master of the revels in Ireland in 1662, he continued to be the same plodding and practical man of business. After the great fire of 1666 had reduced him to beggary, he contrived in a short time to set up a printing-press; and in the capacity of cosmographer to the king, published a large atlas in several folio volumes, and a description of the roads in England from his own actual survey. His death took place in 1676.

OHIO, one of the United States of North America, situated on the river of the same name, which separates it on the S. and S.E. from Kentucky and Virginia; on the E. it has Pennsylvania; N., Lakes Erie and Michigan; and on the W., Indiana. It has an area of 39,964 square miles, being somewhat greater than that of the kingdom of Portugal; and, in all respects, it is one of the most important states of the valley of the Mississippi or of the American Union.

Ohio.

The face of the country is delightfully varied, and presents a table-land from 600 to 1000 feet above the level of the sea. A ridge of high lands divides the waters flowing north into Lake Erie from those flowing south into the Ohio. There is a ridge crossing the state in the latitude of Columbus, south of which the surface is diversified by hills and valleys. Swamps and morasses occasionally occur, forming, however, only a twentieth part of the whole surface. The river-bottoms are extensive and very fertile. Prairies are numerous; but the country was originally covered with magnificent forests, which are still far from being extinct. Physical aspect.

The Ohio River and Lake Erie receive the waters of the state. Those streams which enter into the Ohio are the Muskingum, Hockhocking, Scioto, Miami, &c. The Muskingum is navigable 75 miles for steamers, and for small boats nearly to its source. The Hockhocking courses through a hilly and beautiful country, and is a deep and narrow stream. The Scioto can be ascended to nearly its source, and has many thriving towns on its banks. Its valley is wide and fertile. The Little Miami is less adapted to navigation than to mill-sites. The Big Miami enters the Ohio in the S.W. corner of the state, after a course of 100 miles. The northern rivers are the Maumee, Sandusky, Cuyahoga, which are in part navigable, but furnish the most abundant water-power for manufacturing purposes. The other streams are the Portage, Black, Rocky, Vermillion, &c.

Geology and mines.

Over nearly the entire surface of the state there lies a deposit of various thickness, known by the name of alluvium, believed to have been made by currents of water. One of the most important strata is a transition limestone, equivalent to the mountain limestone of Europe. It crops out in places, forming, at small cost, a valuable building material. East of the Huron and Olantangy rivers the lime stratum dips under one of shale or clay-slate; farther east this passes under a stratum of sandstone; still farther, the sandstone is overlaid by a conglomerate, and then by the lower coal series; and, finally, the upper coal series passes beyond the eastern and south-eastern boundary of the state. One-third of Ohio is therefore within the great coal basin, of which Wheeling, Virginia, is the centre. In several of the southern counties are extensive beds of the best iron. In Western Ohio are found gypsum, salt, and lead. It is estimated that the beds of workable coal would be sufficient to last 10,000 years, supposing Ohio to use as much as is now used in England and Wales. By the census of 1850, it appears that Ohio produced as follows:—

	Establishments.	Capital.	Value of products.
Pig iron	35	L.313,123	L.261,632
Iron castings	183	429,923	639,444
Wrought iron	6	34,331	26,632
Salt	32	39,320	27,558

The county of Tuscarawas is 550 square miles in extent, and in every part of it, it is said, coal may be found. Professor Mather, in his report on the geology of the state, estimates the quantity of coal in this county alone at 80,000 millions of bushels! In 1840 the production of coal in Ohio is stated at 2,382,368 bushels, in 1848 at 6,538,968, in 1857 at 40,000,000 bushels; and the production of iron has swelled to the aggregate of 100,000 tons. The coal is bituminous. A belt of ironstone, averaging 12 miles in width, is 100 miles or more in length. Salt springs are numerous, and salt-works are frequent and successful. Marble, freestone, and gypsum occur.

Ohio is noted for the fertility of its soil. Where the transition lime rock is the upper stratum, as it is in nearly half the state, the soil is remarkably adapted to wheat and grass; and, indeed, seven-eighths of the state are considered well adapted to the growth of wheat. What is known as

the Connecticut Reserve, having a shale and sandstone basis, is less fertile, yet producing fruits and grains suitable to the climate. About 25,000,000 acres of land in the state could be brought into cultivation, and would support many millions of inhabitants.

Climate. On account of its elevation, the climate of Ohio is several degrees lower in average temperature than on the same parallel in the Atlantic states. The summer is subject to tornadoes, but the autumn is always serene and pleasant, though the winters are occasionally severe. Along the valley of the Ohio the temperature is milder than in the interior, but fever and agues prevail to some extent in this section. The climate otherwise is very healthy,—as much so as that of the majority of the states.

Forests. In the forests are found black walnut, oak, hickory, sugar and other maple, beech, poplar, ash, sycamore, papaw, buckeye, cherry, dogwood, elm, hornbeam. The cypress is almost the only evergreen, and it is but scanty. Medicinal roots, such as ginseng, valerian, columbo, snake-root, blood-root, &c., are found. Fish and game are abundant.

Agriculture. At the last federal census (1850), it appeared that there were in Ohio 143,807 farms, having under cultivation about 10,000,000 of acres, with about 8,000,000 more inclosed, but unimproved. The average number of acres to each farm was 125: average value of farm, L.518; and of farming implements, L.37. Gross value of all the farms in the state, with their implements and machinery, L.77,500,000. The number of horses, asses, and mules, was 466,820; milch cows, 544,490; working oxen, 65,381; sheep, 3,942,929; and swine, 1,964,770. The total value of live stock was L.9,192,027; of animals slaughtered, L.1,549,839. The quantity of wheat raised was 14,487,351 bushels; of rye, 425,918; oats, 13,472,000; Indian corn, 59,078,695; potatoes, 5,245,760; barley, 212,440; buck-wheat, 638,060; hay, 1,443,142 tons; maple sugar, 4,588,000 lb.; tobacco, 10,454,449; wool, 10,196,371; silk cocoons, 1552; and wine, 11,524 gallons.

Only another of the United States exceeded Ohio in the production of wheat. The other agricultural products are hops; clover and grass seed; pease and beans; market, nursery, and orchard products; flax seed, flax, and hemp. The produce of the vineyards is large, and commands a market in all parts of the Union.

Manufactures. Ohio, in the possession of coal and iron, may be said to have few rivals in capacity as a manufacturing state, when the full fruition of her reasonable hopes are realized. In 1850, she manufactured cotton goods to the value of L.231,462; pig-iron to about the same amount; castings, L 639,435; wrought-iron, L.26,632. She distilled or brewed nearly 100,000 barrels of ale, and 12,000,000 gallons of whisky, &c. The gross statistics of all the manufactures are as follows:—Establishments, 10,622; capital, L.6,045,733; raw material used, L.7,224,586; hands employed, 51,500; wages paid, L.2,805,758; annual product, L.13,051,507.

Commerce. Ohio being an inland state, must show very low figures in the foreign commerce of the Union. For the inland or home trade she enjoys advantages on account of her position with reference to the Ohio, the Mississippi, and the lakes, together with her great works of internal improvements, enjoyed by few, if any, of the other states. One of her leading authorities says, at the close of 1857, that her production of corn has reached to 90,000,000 bushels, and of wheat to 22,000,000. He estimates the total agricultural, mining, and manufacturing produce of Ohio for that year at L.40,800,000; and says that Ohio is now worth L.200,000,000, and that three-fourths of it have been made out of the profits of labour applied in the industrial pursuits. She exports L.12,500,000 of products, besides enjoying the commerce of her neighbours.

The annual statement of commerce, published at Cincinnati, shows that the total produce received at that city in 1856-57 reached L.16,060,444; and that the exports were L.11,800,447. In the city and vicinity 500,000 barrels of whisky are distilled, consuming 8,000,000 bushels of corn and other grain. Number of hogs packed, 344,512. The city is increasing as a wheat, flour, and tobacco mart. Over 500,000 gallons of wine are produced from the vineyards in the vicinity, giving employment to a large number of persons, and producing large returns to capital.

Internal improvements. The Ohio Canal was completed in 1832, from the Ohio River to Lake Erie, 307 miles. Its branches or feeders are,—the Columbus branch, 10 miles in length; the Lancaster branch, 9 miles; the Athens extension to Hocking, a prolongation of the Lancaster, 56 miles; the Zanesville branch, of 14 miles, connects the Ohio Canal with the Muskingum improvement, by which another channel is opened to the Ohio River at Marietta; the Walhonding branch is 25 miles in length.

The Miami Canal connects Cincinnati with Lake Erie, 270 miles, and was completed in 1832, with several branches. The whole number of miles of canals constructed by the state is 827, at a cost of over L.3,000,000. The other canals, which are private property, are the Sandy and Beaver, 76 miles, extending from the Ohio Canal to the Ohio River, at the mouth of the Beaver; the Mahoning Canal, 77 miles. The canals have, however, in part yielded to the railroads, and are in general far from being works of the first class.

The oldest railroads are the Little Miami, from Cincinnati to Springfield, 84 miles; the Mad River, from Lake Erie to Springfield, 134 miles; the Mansfield and Sandusky; the Lake Erie and Kalamazoo, from Toledo, on Lake Erie, to Adrien, forming a junction with the Michigan Southern Road, to which it forms an outlet to the roads of Ohio, 35 miles. It would occupy too much space, however, to enter into a detail of the numerous railroad routes now in operation in Ohio. They constitute several great lines, running through the States from east to west, and from north to south, bringing nearly every county and town in its limits within reach of railroad improvement. Perhaps one of the most important of all these great works is the Ohio and Mississippi Railroad, 330 miles in length, which has been lately completed, and connects by a direct route the cities of Cincinnati and St Louis. The railroads in progress or in operation in Ohio, at this time, make up an aggregate length of 3000 miles; the surface of the country being most favourable to their construction. There are no lines of pre-eminent importance, because it is said that trade and commerce are not, as in other states, forced into peculiar channels by the natural configuration of the country.

Cities. Among the cities are Cincinnati, which is known as the "Queen of the West," supposed now to have a population of over 200,000, making it the fifth city of the American Union; Columbus, the capital of the state, is the centre of a rich country, which is daily adding to its opulence and extent; Dayton is at the meeting of various railroad lines, and is therefore accessible from every point; Zanesville, on the Muskingum, is in the midst of a rich and populous valley region; Chillicothe, on the Scioto, is inclosed by picturesque hills; Springfield is at the junction of the Mad River and Lagonda Creek, which affords every variety for mill-sites; Stenbenville and Portsmouth are on the Ohio; Sandusky city is on Lake Erie; and Toledo on the Maumee River, at the terminus of the Wabash and Erie Canal.

Education, religion, &c. The amount appropriated for schools in Ohio from the several state funds reached, in 1855, L.544,540. The whole number of common schools was 12,012; number of scholars attending, 357,547 males, and 311,477 females. Total number of school-houses 7830, which had been erected at a cost of L.464,561. There are 91 high schools,

Ohio. having about 4000 scholars ; and 88 schools for coloured children, with about the same number of attendants. There were also a large number of German schools, adapted to that class of population.

Twenty-six daily newspapers were printed in 1850, 10 tri-weekly, 201 weekly; total of all classes, 261, printing annually 30,447,407 copies. The total number of libraries, other than private, was 352, having 186,828 volumes. The whole number of paupers reported was but 1673.

There is a lunatic asylum at Columbus, which had at the last statement 261 inmates. Two other institutions of like character have been opened at Newburg and Dayton. The Ohio penitentiary at Columbus has about 600 inmates. A library and schools are attached to the prison, and the convicts are instructed in the elementary branches. The state derives a small revenue from the institution. There is a deaf and dumb asylum, with 148 occupants; and a blind asylum, containing 72.

The value of church property in Ohio, by the census of 1850, was L.2,413,812, and the number of the church sittings was 1,457,769; the Methodist being the predominating sect, giving, with the Baptists, one-half of the whole number of seats.

There were, in 1850, 26 colleges, with 3621 pupils ; 206 academies and private schools, with 15,052 pupils; 66,020 persons in the state over twenty years of age were incapable of reading and writing, or about 3 per cent. of that class, which compares very favourably with other western states.

Revenue. The total revenue of the state of Ohio in the year ending with January 1856 was L.756,492, and the expenditure L.731,681. The state cannot, by its constitution, contract debt for internal improvement. Total debt in 1856, L.3,390,334; value of the real estate at the same time, L.120,387,191; and of the personal estate, L,58,962,250. Total taxes of all sorts, L.1,765,520.

History. After the western exploration of Marquette (1673) from Canada, and the expedition of D'Iberville to the mouth of the Mississippi and up its stream, the French began the construction of forts throughout the extensive region which they embraced. Thus was founded their claim to Ohio; whilst the English, on the other hand, claimed it from grants made by their crown, which extended from sea to sea, and from a cession made by the six nations of Indians, who claimed the entire sovereignty of the Ohio valley. The English Ohio Company having made a settlement on the Great Miami, it was destroyed by the French in 1752, at which time war occurring between the two nations, many hostile expeditions were conducted with different results. The defeat of Braddock was followed by the victories of Dunmore. On the return of peace in 1763, the whole of Canada was ceded to England, and with it all the territory to the east of the Mississippi River. After the War of Independence the whole of the western lands held by the several states were ceded to the federal government. Surveys and sales of these lands being at once made, the Ohio New England Company purchased a tract lying adjacent to the Scioto and Muskingum rivers, where, in 1788, Marietta was begun, the first permanent settlement in Ohio. Governor Arthur St Clair was appointed territorial governor.

In 1787 John Cleves Symmes purchased from Congress a million of acres in Ohio, northward from the Ohio River. and between the two Miamis, in which region was founded the second settlement at Columbia, about five miles distant from the present city of Cincinnati. Mathias Denman purchased for 500 dollars the site on which Cincinnati is built, and the first cabin was erected in 1788. Other settlements immediately followed. The Indians, in despite of all treaty stipulation, continued to harass the settlers. Block-houses were constructed; and in 1789 Fort Washington, as a means of protection, was begun. These aggressions continuing, General Harmar, with 1300 men, marched against the Indian towns, but was compelled to retreat. In 1791 General St Clair, at the head of an army of 3000 men, undertaking a similar enterprise, was attacked by a combination of nearly all the north-western tribes, and after a gallant struggle, sustained a most disastrous defeat. The result of those reverses was severely felt in the settlement, and for some time the tide of emigration actually ceased. In 1794 General Wayne assembled an army at Greenville, and soon obtained a decisive victory over a force of 2000 warriors, at the rapids of the Maumee. Not until the country was laid waste, and forts on every hand were seen springing up, did these hardy warriors abandon their futile struggles. "When we consider," says an authority, "the fierce and unrelenting warfare waged by the Indian tribe upon the white settlements of the West, during thirty-seven years of almost uninterrupted conflict from 1757, when the first white man was killed in Kentucky, down to the period of Wyne's victory, we may form some faint idea of the toil and perils and sufferings of the bold and hardy race of the pioneers who effected the colonization of the Western World. An Indian chief, at the conclusion of a treaty yielding up the right of soil in Kentucky, said to Boone,—'Brother, we have given you a fine land, but I think you will have trouble to settle it;' and his prediction was fully verified there and elsewhere."

Ohio. Constant streams of population began now to pour into Ohio. Connecticut sent many to her reserved tract bordering on Lake Erie. In 1798 the inhabitants of the territory numbered 5000, with eight organized counties. The first meeting of territorial legislature was held in September 1799. William Henry Harrison, then secretary of the territory, and afterwards president of the United States, was at that time elected to Congress. In 1802 the federal government authorized a convention to form a state constitution. It sat at Chillicothe; and Ohio was admitted into the Federal Union soon after. The first legislature met in the same place in 1803; and two years later the United States acquired, by another Indian treaty, the reserve west of the Cuyahoga River, and subsequently the Maumee and Sandusky region. In 1811 the Indians were defeated by General Harrison at Tippecanoe; and in 1816 the seat of government was removed from Chillicothe to Columbus, where it now is.

Population.						
	1800.	1810.	1820.	1830.	1840.	1850.
Whites...	45,028	228,861	576,572	928,329	1,502,122	1,950,050
Coloured	337	1,899	4,862	9,574	17,345	25,279
Total.	45,365	230,760	581,434	937,903	1,519,467	1,980,329

Density to the square mile in 1840, 38·02; 1850, 49·55. Of the total population, but 1,219,452 were born in the state, and 538,134 in the other American states; and 218,312 were born in foreign countries. Of these, about 120,000 were of German origin.

Ohio, a river of the United States of North America, is formed by the confluence of the Alleghany and Monongahela, which rise in the Alleghany Mountains, and unite at Pittsburg, in the west of Pennsylvania. It then flows generally towards the S.E., separating the states of Ohio, Indiana, and Illinois, on the right, from those of Virginia and Kentucky, on the left; and falls into the Mississippi 1216 miles above its mouth; N. Lat. 37., W. Long. 89. 10. Its whole length is more than 950 miles; but its length in a straight line is not more than 614. At the confluence of the two great branches, the Ohio is somewhat more than 600 yards wide, and it immediately assumes that broad, placid, and beautiful aspect which it maintains to its

Ohlau ‖ Oils.

junction with the Mississippi. Its breadth varies exceedingly, being in some parts 1400 yards, whilst in others it is only 400 yards across. Between Pittsburg and its mouth it is diversified with about 100 considerable islands, besides a great number of tow-heads (or barren sandy islands overgrown with willows) and sand-bars, which in low stages of the water greatly impede navigation. Some of these islands are of exquisite beauty, and afford most lovely situations for retired farms. The passages among them, and the sand-bars at their head, are great difficulties in the navigation of the river. Notwithstanding these obstacles, however, it is well adapted for boat navigation, the current being remarkably smooth and gentle, excepting at Louisville in Kentucky, where it is broken by falls, the water running for several miles with great rapidity, although not so much so as to be insurmountable by boats. A canal round these falls, a work of great magnitude and utility, has been completed. The annual range of the Ohio, from low to high water, is about 50 feet; the extreme range is 10 feet more. When lowest it may be forded at several places above Cincinnati. Throughout the year it is subject to sudden and very considerable elevations and depressions. Generally, the navigation is obstructed by floating ice for five or six weeks in winter. When the river is at its mean height, its current is about 3 miles an hour; when higher and rising it is more; and when very low it does not exceed 2 miles an hour. The Ohio and all its tributaries cannot, it is believed, have less than 5000 miles of waters navigable for boats; and taking all circumstances into account, few rivers in the world can vie with it, either in utility or beauty. From its very commencement it affords most delightful prospects. Rivers of a romantic and beautiful character flow into it almost at equal distances, like lateral canals. The aspect of the country on the banks has much grandeur, softness, and variety. Of the rivers and creeks which join it, the following are all navigable by steamboats for considerable distances, viz., the Muskingum, Great Kanawha, Big Sandy, Scioto, Miami, Kentucky, Green, Wabash, Cumberland, and Tennessee. The last is by far the largest and most important tributary of the Ohio, watering considerable portions of Alabama, Tennessee, and Kentucky. Of creeks and smaller rivers there are probably nearly two hundred which enter the Ohio; but a list of them would only be a dry catalogue of uncouth names. The area watered by the Ohio and its affluents is estimated at 200,000 square miles.

OHLAU, or Olau, a town of Prussia, province of Silesia, government of Breslau, on the right bank of the Ohlau and left of the Oder, 18 miles S.E. of Breslau. It has a large castle, several churches, an orphan hospital, and a poor-house. There are extensive tobacco manufactories and a flour-mill, besides breweries, distilleries, &c. Pop. 6079.

OHRDRUF, a town of Saxe-Coburg-Gotha, in the principality of Gotha, on the Ohra, 8 miles S. of Gotha. It has a castle, a newly-erected town-hall, and several churches and schools. Manufactures of woollen cloth, porcelain, organs, &c., are carried on here; and there are also numerous mills and bleach-works. The trade is considerable in wool, coals, &c. Pop. 4559.

OICH, Loch, a lake of Scotland, county of Inverness, between Loch Ness and Loch Lochy. It is about 4 miles in length by 1½ in breadth; it receives the Glengarry River, and discharges its waters by the Oich into Loch Ness. This loch is connected by the Caledonian Canal with Loch Ness and Loch Lochy.

OILS. Under this head is ranged a group of organic compounds of great interest, both on account of their great economic value, and from the fact that they occur abundantly both in animals and plants. They consist chiefly of carbon and hydrogen, but more or less of oxygen is generally associated with them, and causes considerable variation in their qualities. They are either solid or liquid, and in the former condition are more frequently termed *fats*, These fats are more abundant in the animal than in the vegetable kingdom. Oils, whether liquid or solid, usually consist of three other substances, two of which, *stearine* (στέαρ, suet), and *margarine* (μάργαρον, a pearl), are solid; and the other, *elaine* or *oleine*, is liquid at ordinary temperatures. They are all from 6° to 9° lighter than water, and their liquid or solid condition depends upon the proportion in which their component parts are mixed. Thus, in the fats the oleine exists in small quantity, and in the liquid oils it is the chief constituent. A certain degree of heat is necessary to the mixture, for at low temperatures there is a tendency to separation: the stearine and margarine are precipitated and solidified, and, if pressed, can be entirely freed from the oleine. Both oils and fats, when boiled with water and alkali, undergo the peculiar process of *saponification*, or, in other words, solidify, and become converted into soap; during this process a liquid of a sweet taste, called glycerine, is given off. (See Glycerine). Glycerine exists in oil and fats as a base to which stearic, margaric, and oleic acids are united, forming stearine, margarine, and oleine.

Oils.

The principal uses to which oils and fats are applied are soap-making, illumination by candles or oil, lubricating machinery, and dressing cloth. They are easily separated by moderate pressure from the animal or vegetable tissues which contain them, but are not usually pure until they are rendered so by clarifying.

Fixed and volatile oils.

Of the animal oils, those are chiefly solid which are yielded by the mammals and birds; whilst those derived from reptiles and fishes are for the most part liquid at the ordinary temperature. The true oils and fats are unchanged when heated even to a temperature above 400°; but there is another group of compound substances, termed *essential oils*, yielded by the vegetable kingdom, which are volatile at ordinary temperatures; hence the term *fixed oils* is often applied to the former, and *volatile oils* to the latter. The volatility of the essential oils renders distillation a ready means of procuring many of them. They resemble the fixed oils in many respects, but differ materially in others; for instance, they do not undergo saponification when treated with alkalies; like them, however, they often separate at low temperatures into solid and liquid portions,—the former called *stearopten*, the latter *elæopten*. They are very slightly soluble in water, and they differ materially in the sensation they produce on the skin. Instead of the smooth soft feel of the true oils, they are harsh and rough to the touch. The essential oils are mostly pure hydro-carbons, but many are capable of absorbing oxygen when exposed to the air, which darkens their colour, and renders them resinous in appearance, a result which may be seen generally around the mouths of bottles in which they are kept. Some are obtained already oxidized, and some are found to contain sulphur: hence they have been classified as *pure hydro-carbons*, when free from oxygen; *oxidized essences*, when obtained in combination with oxygen; and *sulphuretted essences*, when combined with sulphur. The combinations which the essential oils enter into render them peculiarly interesting to the student in organic chemistry. They appear to be the cause of all the more remarkable odours and flavours which characterize plants; and as they can generally be separated easily, they are very valuable in an economic point of view, affording us the means of concentrating and retaining the perfumes of the most evanescent flowers, and in the same way of preserving the most pungent and delicate flavours.

Essential oils are in some instances procured by simple pressure, as those from the rind of the orange tribe; others are distilled with water, and float upon the condensed water in the receiver. Some, however, are so easily destroyed by these processes, that they can only be obtained by the power

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which the fixed oils have of absorbing them. Thus, essence of jessamine is obtained by placing layers of the freshly-gathered flowers between layers of cotton-wool saturated with the fixed oil of almonds or of poppy seed, both of which are themselves odourless. They, however, soon absorb the essential oil naturally emitted from the flowers, and become highly perfumed. Fresh layers of flowers are supplied until the fixed oil is saturated, when it is pressed out from the cotton-wool.

Rock oil.

Besides the fixed oils and fats, and the essential oils, there is a mineral product called rock oil; it is not, however, properly speaking, an oil, but is a variety of petroleum, which exists abundantly in some bituminous shales. Works have been established in Dorsetshire and other parts of the kingdom for obtaining this material, but without much success. Large quantities are, however, brought from Rangoon, in the Burmese empire, chiefly to Liverpool, where nearly 700 tons weight were imported in 1857. Works exist at St Helen's, near Liverpool, and other places, where from this material, which is of a dark greenish-brown colour, and nearly the consistency of butter, a light amber-coloured oil-like liquid is obtained, said to be very useful as a lubricant for machinery. A considerable proportion of paraffine is obtained from it, and it yields a very volatile naphtha.

Sources of oils.

In enumerating the oils, those produced from the animal kingdom will be first mentioned, and in the order of zoological classification; then the fixed vegetable oils; and finally the three classes of essential oils. Of the twelve orders into which naturalists divide the mammalia, only four comprise animals which yield oils of economic value. These orders are Carnivora, Cetacea, Ruminantia, and Pachydermata.

Animal oils.

Of the carnivorous animals yielding oleaginous products, we have first the bear. The black bear (*Ursus Americanus*, Gmelin), a native of North America, yields an abundance of grease or soft fat; which is collected by the hunters who pursue the animal for its skin and hams, and is occasionally imported into this country, not, as some may suppose, to be used by the hair-dressers and perfumers for pomades, but for the more useful manufacture of candles, &c. But the principal oil-producing carnivora are the seals, several species of which are killed on purpose. The quantity of seal oil imported is very great. Most of it comes from Newfoundland. The species which chiefly yield it are *Callocephalus Grœnlandicus*, *Callocephalus vitulinus*, *Phoca barbata*, and *Arctocephalus Falklandicus*. The part which yields the oil in these animals is the *blubber*, a peculiar layer of oil-cells which lies immediately under the skin of the animal, and in fact constitutes a portion of the skin itself. Seal oil is liquid, and, when pure, of a pale straw-colour. The first drawings from the blubber give the purest oil, which is obtained without pressure; but the succeeding drawings from the blubber-cask are more or less deeply coloured brown by the decomposition of the oil-cells.

The Cetacea are remarkable for the extent of this peculiar skin-development called blubber, which in some species is one or two feet in thickness. This is not, however, the only source of the whale oil; for in the great-headed cachalot or spermaceti whale (*Catodon macrocephalus*, Cuv.), the gigantic head, which nearly equals the body in bulk, has an enormous receptacle on the upper part of the skull, from which oil is obtained. This receptacle consists of a dense bag, divided into numerous large cells or compartments, in which the oil exists in a semi-fluid state, owing to the large quantity of stearine or *spermaceti* which it contains, and which can easily be separated from it by simple draining or slight pressure. The quantity of oil yielded by some of the larger whales, especially the cachalots, is enormous, but is often erroneously stated, owing to a misunderstanding of the fact that quantity in liquid oils is calculated by the *tun* measure, and not by the *ton* weight, as with solid oils or fats A cachalot commonly yields 20 tuns, or 5040 gallons; and single whales have been known to yield 30 tuns (7560 gallons). The following oils derived from the whale tribe are known in commerce:—*Sperm Oil*, and its stearine, *Spermaceti*, from the cachalot; *Train* or *Common Whale Oil*, from the Right Whale (*Balœna mysticetus*) and other species; *Pot-head Oil*, from both *Globicephalus deductor* and *Globicephalus Swineval*; and *Porpoise Oil*, from *Phocœna communis*. These oils are usually imported as train or sperm oils; but the brokers are well skilled in distinguishing them.

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Of the ruminating animals, we have only two species which yield oleaginous products; but they are unequalled in value by any others. They are the ox (*Bos taurus*, Linn.), and the sheep (*Ovis ammon*, Linn.) The fat of both these animals melted down constitutes the tallow of commerce. They are so generally mixed together that there is no possibility of ascertaining the exact amount yielded by each. We receive our largest supply from Russia; but we import considerable quantities from Denmark, Prussia, the Hanse Towns, Holland, Turkey, South America (particularly Buenos Ayres and Monte Video), the Cape of Good Hope, the East Indies, Australia, &c. That imported from the ports of Monte Video and Buenos Ayres is chiefly, if not altogether, ox tallow; whilst that from Australia is principally from the sheep. Besides the enormous quantity imported, we have to take into consideration that which is produced in Great Britain, which has been computed to be equal to the amount imported.

From the bones of the feet of oxen a valuable oil is obtained. It contains comparatively little of the harder portion (stearine), and is in a fit state to be used for machinery. It is procured by boiling the bones, and skimming off the fatty oil as it rises to the surface of the water. It is called neats-foot oil; and from the fact that it remains liquid at a temperature below 32°, and is not liable to rancidity, it is peculiarly well adapted for turret clocks and other machinery much exposed to cold. The supply from such a source is necessarily limited.

Of the Pachydermata only two yield oily products of any commercial importance. The first of these in point of value is the common hog (*Sus scrofa*, Linn.), the fat of which, under the name of *lard*, is very extensively used. Considerable quantities are consumed in articles of food. Most of the ointments of the pharmaceutist have lard for their base; and when too rancid for these purposes, it is used for greasing machinery, especially the axles of railway carriages. In the United States the production of lard is immense; and its stearine, which is easily separable from the elain, is extensively used in the manufacture of candles. The liquid stearine, under the name of lard oil, is used for the finer parts of machinery, and for that purpose is extensively imported into this country from Europe and America. The fat of the horse does not, when melted, possess the same firm consistency as that of the ox, sheep, and swine. The proportion of stearine in it being comparatively small, it is only within the last eight years that it has attracted any attention; but now it constitutes an important article of trade with Buenos Ayres and Monte Video, whence it is imported under the names of horse or mare's grease. The latter name is, however, more generally applied. From its liquidity, it is extremely penetrating; hence the ordinary packages for grease and tallow were found to be insufficient, as the casks were frequently half empty on their arrival. This checked its introduction for some time; but it is now put into square boxes lined with tin, and arrives without loss. It is found to answer very well as a lubricant for machinery.

From the classes comprising the birds and the reptiles (Aves and Reptilia) neither oils nor fats of any importance are obtained, although the domesticated birds sometimes produce it in abundance. That of the goose, under the name of goose-grease, is occasionally heard of as a useful domestic remedy for various ailments.

The class of fishes (Pisces) is a considerable source of oil, always of a clear liquid quality. It is nearly all yielded by one species, the common cod-fish (*Gadus Morrhua*, Linn.). The *Cod Oil*, and the *Cod-liver Oil* of commerce, are both obtained from the liver of the fish; the latter, which is now so extensively used medicinally, being only prepared with a little more care. Its principal value as a remedial agent appears to depend upon its nutritive qualities, and the digestive powers of a portion of *pepsin*, or biliary matter, which is always present, and which may be detected by the application of a drop of concentrated sulphuric acid, when, if the oil be really cod-liver oil, a beautiful purple colour will be immediately produced. The number of cod-fish captured is incalculable. The cod-fishers, in opening the fishes to salt and dry them, carefully preserve the livers, for which an extra boat is usually in at-

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tendance; these are taken on shore, and piled up in immense masses exposed to the sun. The heat soon makes the oil run from the livers in considerable abundance, and for a short time it is very clear, and of a light straw colour,—this is the first quality, and is kept by itself. As the livers begin to decompose, however, they give a darker colour to the oil, and several qualities are obtained, the last of which is thick, turbid, and extremely offensive to the smell, and is known under the name of cod-pitchings. A small quantity of oil made from the common herring (*Clupea harengus*, Linn.) is imported from time to time from North America; but its strong and unpleasant odour prevents it from being much used.

Vegetable oils.

The vegetable sources of oils are very numerous, and some are of great importance.

Fixed Vegetable Oils.—Of these the most important is *Olive Oil*, procured from the ripe fruit of the olive (*Olea Europœa*, Linn.), which is cultivated for this purpose through all the countries of Southern Europe and Northern Africa. Its native country is Asia. On Lebanon and the Mount of Olives, and in the neighbourhood of Aleppo, the olive tree still grows wild. Its general diffusion through the countries suitable to its growth is no doubt attributable to the Romans, although the Carthaginians and others had previously procured and cultivated it. Pliny says (book xv., Bohn's edition), "Fenestella tells us that in the year of Rome 173, being the reign of Tarquinius Priscus, it did not exist in Italy, Spain, or Africa; whereas at the present day it has crossed the Alps even, and has been introduced into the provinces of Gaul and the middle of Spain. In the year of Rome 505, Appius Claudius, grandson of Appius Claudius Cæcus, and L. Junius, being consuls, 12 pounds of oil sold for an *as;* and at a later period, in the year 680, M. Seius, son of Lucius the curule ædile, regulated the price of oil at Rome, at the rate of 10 pounds for the *as*, for the whole year. A person will be the less surprised at this, when he learns that twenty-two years after, in the third consulship of Cn. Pompeius, Italy was able to export oil to the provinces." Its value has never decreased; and, next to corn, olive oil is still perhaps the greatest necessity of the nations of Southern Europe. It has been described as the cream and butter of Spain and Italy; and the quantity consumed in those countries as food, entering into their cookery in every imaginable way, is immense. There are several varieties in cultivation, which vary much in quality. That which yields the sweet Italian and French salad oils is the var. β. *longifolia*, Aiton. Its fruit, when pickled unripe, is also most highly prized. The inferior oils of Spain are made from the large olive, var. δ. *latifolia*, Aiton. In Italy and France the oil is obtained by crushing the fruit in mills,—the grinding stones of which are so set that they will thoroughly crush the pulpy part of the fruit without breaking the stone or kernel in the centre. The fruit, which is gathered for the purpose when very ripe, is not unlike a small damson in shape and colour, and the stone in the centre is very hard. After crushing in the mill, the pulp is put in bags made of rushes and slightly pressed, when the fine or virgin oil flows out abundantly. Afterwards the cake or *marc* is again broken up, mixed with water, and returned to the press, and an oil of an inferior quality is obtained. The cake or *marc* is once more broken up and mixed with water, after which it is placed in vats to ferment, and then again pressed. The result is an oil of a very inferior sort, only useful to the soap-makers. The oil of the olive is liquid at the ordinary temperature, but becomes solid a few degrees below 32°. In Spain the process is less carefully conducted. Instead of being gathered by hand, the olives are beaten from the trees, and are consequently much mixed—ripe, unripe, and decayed. They are left in large heaps on the ground to ferment, which partly breaks up the oil cells; they are then ground and pressed, and yield a very inferior oil. The finest virgin oil for table use is imported from Leghorn and from France. The common oil is chiefly used in England for dressing woollen cloths, for which purpose vast quantities are required in Yorkshire, the west of England, and other cloth districts. On the Continent it is also employed in making soap. In 1856 the imports were as follows:—From France, 358 tuns; Portugal, 3175 tuns; Spain, 2,301 tuns; Sardinia, 907 tuns; Tuscany, 1,973 tuns; Two Sicilies, 6,093 tuns; Turkey, 491 tuns; Morocco, 2579 tuns; Malta, 360 tuns; Ionian Islands, 2900 tuns; other parts, 278 tuns; in all, 21,415 tuns, or 5,395,580 gallons, valued at L.1,124,755.

Palm Oil is obtained from the fruit of the oil palm (*Elæis Guineensis*, Linn.), a native of Western Africa, by crushing the thin fleshy covering which surrounds the hard stone or seed, and by pouring boiling water upon the pulp, upon which the oil floats and is skimmed off. In this process, however, much of the colouring matter of the drupe, which is a fine orange-yellow, is retained, which, besides its colour, imparts to the oil a sweet violet-odour. Palm oil, when imported, is of the consistence of butter. Vessels arrive entirely laden with it. It is put in casks of various sizes, but usually very large, and made to suit the stowage of the vessels. Spirits, tobacco, cutlery, cloths, beads, cowries, arms, gunpowder, and other articles, are given in barter to the natives in exchange for the oil. This trade has now obtained an immense importance, owing to the valuable discoveries by which the oil can be deprived of its colour, and a solid part, called palmitic acid, converted into candles of a very superior quality. The addition of sulphuric acid entirely carbonizes the yellow vegetable colouring matter. It is then submitted to the action of steam, at a temperature of 612°, in a still of peculiar construction, which carries over the particles of oil with the steam, leaving behind the charcoal or carbonized vegetable matter. Previous to the distillation, however, lime is added to neutralize the acid, and that also remains behind. The material which comes over runs from the still as a clear colourless oil, which upon cooling has the colour and consistency of lard in cold weather. This is cast into square cakes about 1½ inch in thickness, and 18 inches square. The cakes are placed between mats made of coir, or cocoa-nut fibre, and submitted to the action of powerful hydraulic presses, which force out the *elain*, a liquid about the colour and consistency of linseed oil. The mats are then taken from the press, and the cakes, which are now much harder, are remelted and made into candles. Nothing can give a better idea of the extent to which this manufacture is carried on than the fact, that Messrs Price and Co., at their works in London, and at Bromboro' Pool, Cheshire, are now making 150 tons of these candles per week, and give employment to upwards of 2000 persons. Great quantities are also consumed in the manufacture of soap. When it is remembered that each drupe will only yield about $\frac{1}{16}$th part of an ounce in weight, and that each palm only produces three or four pounds at one crop, the number of palms in the forests of Western Africa must be immense, and the industry called into action by this want of civilized man must exert a most beneficial influence over the destinies of the African races. The drupes are borne in immense clusters, each surrounded by sharp bracts, and they greatly resemble gigantic pine-apples both in shape and colour.

Cocoa-nut Oil is produced from the white kernel which lines the shell of the large cocoa-nut (*Cocos nucifera*, Linn., Nat. Ord. *Palmaceæ*). This kernel is ground in mills in Ceylon, where it is largely cultivated for its oil; and when ground, the mass, called *copperah*, is submitted to considerable pressure. The oil runs at first limpid and liquid, but it afterwards becomes white and solid. It is largely used in making soap, and also in making candles; for the latter purpose the *stearine* only is used. The *oleine*, both of cocoa oil and palm oil, is used for lubricating machinery. It is nearly all obtained from Ceylon, whence it is exported chiefly to this country in large casks and iron tanks.

Linseed Oil is pressed from the seed of the flax plant (*Linum usitatissimum*, Linn., Nat. Ord. *Linaceæ*). It is not imported very largely, being chiefly manufactured in this country from home-grown or imported seed. The seed is first ground in mills, and afterwards submitted to enormous hydraulic pressure. The oil yielded is of a dark brown colour, and is one of the best drying oils. It is therefore of great value to painters, who use this oil almost exclusively in mixing their paints. Linseed is imported in very large quantities from the East Indies, Russia, Germany, Holland, America, and other places. The total quantity received in 1856 was 1,180,180 quarters, valued at L.3,195,634. This does not represent the value of the oil, for the cake or *marc*, which remains after the oil is expressed, is of considerable value for feeding cattle.

Seed Oil is a name applied to the expressed oil of the physic-nut (*Jatropha curcas*, Linn., Nat. Ord. *Euphorbiaceæ*). Within the last six years this oil has been brought into notice as a substitute for the dearer olive oil in dressing woollen fabrics. It has highly purgative properties; and the seeds imported, under the name of croton nuts, produced serious results

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when first landed on the Liverpool quays; the tempting name induced many to eat their blandly flavoured white kernels, and the consequences were nearly fatal to some. The oil, too, at first produced disagreeable effects amongst the workmen, who have a habit of tasting with their fingers the various oils they use. This evil, however, soon cured itself, and the oil is now largely used. It is chiefly imported into Liverpool from Lisbon, but the Portuguese manufacturers obtain the seeds from the Cape de Verde Islands. There is no doubt that vast quantities might be obtained from the West Indies, where the plant is indigenous. It is cultivated in the East Indies, and its oil is called *Bhoga Bhirindi til.* The imports have reached nearly 400 tuns per annum; but owing to the indefinite name given to it, this oil is confounded with others, and the exact quantity cannot be ascertained. The importers also have some interest in suppressing information respecting its source and true character. It is a good drying oil, and would probably, if boiled, be equal to linseed oil for painters' purposes.

Sessamum or *Gingely Oil* is made from the seed of *Sessamum orientale*, Linn. (Nat. Ord. *Pedaliaceæ*). This seed is grown extensively all through India, where its oil is known under various names, as *Tillee Oil, Manchy noonæ, Til ke tel, nullenai, tamool,* &c. The seed is small, not much unlike the flax seed in shape: the colour usually a light drab—but there are dark-coloured varieties. The oil is bland and sweet, and useful for all purposes to which the common kinds of olive oil can be applied. In 1856, 5269 quarters of this seed were imported for expressing the oil; and of the oil itself in 1857, 42,136 gallons, or nearly 166 tuns. The *marc* or oil-cake is much relished by cattle, and is very nutritious.

Niger-seed Oil is expressed from the seeds of *Verbesina sativa*, H. K., or *Guizotia oleifera*, Cassini (Nat. Ord. *Compositæ*), another East Indian seed, also extensively used in that country under the names of *Ram til, Valisaloo Oil, Valisaloo noonæ,* &c. The seed only is imported here. It is black and shining, resembling in shape the common sunflower seed, but is scarcely larger than a caraway seed. The oil is as sweet and liquid as that of the olive, and answers the same purposes. About 700 quarters were imported in 1857.

Safflower-seed Oil is expressed from the seeds of the safflower plant (*Carthamus tinctorius*, Nat. Ord. *Compositæ*), also a native of India, where it is very extensively cultivated, both for its flowers and seed. The latter are of the same shape and size as those of the sunflower, but are white instead of black. They yield a large quantity of a fine clear oil, of a peculiar golden-yellow colour. It has good drying properties, and burns well, but has a peculiar and not very agreeable odour. There is good reason for believing that this oil, known in India under the name of *Koosum Oil*, is the celebrated Macassar oil of the Malays, and, in all probability, of our own perfumers. It has certainly a specific effect upon the growth of the hair. The oil is not often imported, but a large quantity of the seed now finds its way annually to this country; but as the official designation of "seed unenumerated" is applied to this and many others in the returns, the exact quantity cannot be ascertained. Between 300 and 400 quarters were imported in 1857 into the port of Liverpool, and probably a much larger quantity into London.

Rape Oil is expressed from the seeds of *Brassica rapa*, and its variety *B. oleifera*, De Cand. (Nat. Ord. *Cruciferæ*), a common European weed, which is, however, largely cultivated for its seed. It yields a yellowish-brown oil in considerable abundance, valuable for burning and other purposes. Several other *cruciferous* plants, yielding a similar oil, are also largely imported under the same name, and are consequently confounded with it. Thus we have immense quantities of the seed of *Sinapis toria, S. glauca, S. nigra*, sent from India under the name of rape-seed, and the colsa or colza seed (*Brassica campestris*, var. *α oleifera*, De Cand.) is imported from Holland and Germany, and finds its way into our markets under the same designation. The quantity of seed imported as rape in 1856 was as follows:—From Russia, 2556 qrs.; Denmark, 4402 qrs.; Germany, 2267 qrs.; Holland, 1850 qrs.; British East Indies, 251,890 qrs.; other parts, 1955 qrs.;—or 264,920 quarters in all, in which probably not more than 8000 quarters are genuine rape-seed. Besides the seed, a considerable quantity of the oil was imported from the continent of Europe.

Ground-nut Oil is yielded by the seeds of *Arachis hypogæa*, Linn. (Nat. Ord. *Leguminosæ*). The seeds are about the size of a small horse-bean, generally two in a pod. They are much used, when roasted, as food both in South America (its native country), and also in Africa, India, and China, in which countries it is now naturalized and grown to a great extent. The oil is thin and limpid, burns well, and is a good substitute for olive oil, both for the table and other purposes, as it is remarkably free from rancidity. It is almost pure elain, and has accordingly been recommended for watch and clock-work, and other delicate machinery. The quantity of the seeds imported in 1857 was about 2500 tons. Some small lots of the oil have also been imported, but the exact quantity cannot be ascertained. It is known in India under the name of *Katchung Oil.*

Castor Oil is expressed either with or without heat from the seeds of the palma-christi plant (*Ricinus communis*, Linn., Nat. Ord. *Euphorbiaceæ*), a native of the East Indies, where it is known under many names. In Tanjore the native name of that which is obtained by putting the crushed seeds into hot water is *Adivia aumedum.* It is used for burning in lamps. That which is expressed without heat, and is consequently known here as *cold-drawn*, is there called *Arandee ka tel.* Only the cold-drawn is sent to this country, and it is nearly all used for medicinal purposes, in consequence of its valuable aperient qualities. It is now disseminated pretty generally through all tropical and subtropical countries. About 1200 quarters of the seed were imported in 1857, besides large quantities of the oil. Another seed is imported for the purgative oil which it yields, but the quantity is very small. It is the fruit of *Croton Tiglium*, Lam. (Nat. Ord. *Euphorbiaceæ*), also a native of India; the oil is never used except for medicinal purposes. The seeds of *Jatropha curcas*, before-mentioned, are often imported as croton seeds, but not more than a few bushels of the real croton seeds are annually brought to this country.

Poppy-seed Oil, obtained from the seed of the white poppy (*Papaver somniferum*, Linn., Nat. Ord. *Papaveraceæ*), is most likely of Asiatic origin. It is cultivated chiefly for its narcotic juice (opium), but the value of its seed for oil purposes is rapidly increasing; and the fact that it is easily cultivated in France and other temperate parts of Europe, adds much to its interest. Thousands of acres of land in France alone are now annually covered with crops of the white poppy, grown only for its seed, which yields a sweet limpid oil, esteemed by many as preferable for most purposes to that of the olive, especially as a salad oil. The impression which long prevailed, that the seed of a plant producing so poisonous a juice as that of the poppy could not be otherwise than injurious, actually led to legislative enactments against its introduction into France in former times. But, like those in our own country against logwood, they have long since passed away, and poppy oil and logwood are now amongst the most useful of our commercial materials. In 1856, 24,121 qrs. of this seed were imported, of which no less than 24,073 qrs. were from British India. The oil has not been imported, unless in very small quantities, from France.

Almond Oil is expressed from the kernel of the common almond (*Amygdalus communis*, Linn.) The value of the sweet varieties for other purposes causes the small bitter almond to be generally used for expressing this oil, especially as the essential oil can afterwards be distilled from the *marc.* The fixed oil of almonds is chiefly manufactured in France; it is much used by perfumers, as it is very nearly inodorous, and will consequently receive the most delicate perfumes. It is an expensive oil, as it requires 1 cwt. of almonds to obtain 50 lbs. of oil. It is of a light yellow colour, and contains very little stearine, only about 24 per cent. It is often adulterated with the oil of *Guizotia oleifera.* Besides its chief use by the perfumers, it is also, to a small extent, used in the operations of pharmacy. The imports are small, and published returns contain both the fixed and volatile oils, consequently the exact quantity of each cannot be ascertained. Most of that used in Great Britain is home manufactured.

Amongst the less known oils and vegetable fats are the *Madia Oil*, yielded by the seed of *Madia sativa*, Molina (Nat. Ord. *Compositæ*), a native of Chili, and cultivated in Italy for the sake of its oil, which is limpid and sweet. *Gold of Pleasure Oil*, from the seed of *Camelina sativa*, Cranby (Nat. Ord. *Cruciferæ*), a native of the continent of Europe. It does not succeed well in England, but the oil is used for many purposes

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on the Continent, being even employed in culinary preparations. *Oil of Mexican poppy-seed* (*Argemone Mexicana*, Linn., Nat. Ord. *Papaveraceæ*) is a drying oil, and is used in Mexico, its native country, for polishing wood. It is also employed for various useful purposes in the East and West Indies, where it is now cultivated. *Indian Almond Oil*, a sweet limpid oil, is obtained from the kernels of *Terminalia catappa*, Linn. (Nat. Ord. *Combretaceæ*). This tree is a native of India, and is now cultivated in the West Indies. The kernel is not very large, but closely resembles the almond in flavour. The oil has not yet been imported. *Walnut Oil*, expressed from the kernel of the common walnut (*Juglans regia*, Linn., Nat. Ord. *Juglandaceæ*), is extensively manufactured in Circassia, where the tree is very abundant. It is used by the natives for almost every purpose to which oil is applied, but it is not exported.

The following liquid oils were exhibited in the Indian collection at the Exhibition of 1851, but no information given as to their uses or commercial value. *Cheeronjee Oil*, from the seeds of *Buchanania latifolia*, Roxb. (Nat. Ord. *Anacardiaceæ*). *Valuse nune*, from the seeds of *Guizotia abyssinica* (Nat. Ord. *Compositæ*). *Poonseed Oil*, expressed from the nuts of an unknown species of Calophyllum (Nat. Ord. *Clusiaceæ*). *Oondee Oil*, from the nuts of *Calophyllum inophyllum*. *Caju-apple Oil*, from the cashew-nut, *Anacardium occidentale*, Linn. (Nat. Ord. *Anacardiaceæ*). *Neem Oil*, obtained from the pulp of the margosa-berries, or fruit of *Melia azadirachta*, Linn. (Nat. Ord. *Meliaceæ*). *Kurrunj Oil*, expressed from the nut of *Pongamia glabra*, Ventenat (Nat. Ord. *Leguminosæ*). Its chief value is in veterinary medicine. *Country Walnut Oil*, from the kernels of *Aleurites triloba*, Forst. (Nat. Ord. *Euphorbiaceæ*). *Country Walnut Oil*, from the seeds of *Bergera Königii*, Roxb. (Nat. Ord. *Aurantiaceæ*). *Hingun* or *Hingota Oil*, from the seeds of *Balanites Ægyptiaca*, Delile (Nat. Ord. *Amyridaceæ*). *Oil of Ben*, from the seeds of *Moringa pterygosperma*, D. C. (Nat. Ord. *Moringaceæ*). *Mooneela Grain Oil*, from the grain of *Dolichos biflorus*, Linn. (Nat. Ord. *Leguminosæ*).

Solid Oils, or Vegetable Tallows.—*Kokum* or *Cokum Oil*, made from the fruit of *Garcinia purpurea* (Nat. Ord. *Clusiaceæ*), is now frequently imported from India, usually in large candle-shaped rolls about eighteen inches in length, and from one to three inches in diameter. This oil has a sweet balsamic smell, and is said to be wholly used by the candle-makers for their best kind of candles.

Muohwa Oil, or *Bassia Butter*, is made from the large seeds of *Bassia latifolia* and *Bassia longifolia* (Nat. Ord *Sapotaceæ*). This material, which is rather softer than butter, and of a yellow colour, is used in India for food, burning in lamps, and making soap. It was first imported into England during 1857. The quantity, however, was very small.

Chinese Vegetable Tallow, obtained from the seeds of *Stillingia sebifera* (Nat. Ord. *Euphorbiaceæ*), by placing them in boiling water, is white, and harder than common tallow. In China it is used for making candles, and in this country it has been employed to give firmness to softer fats, but the quantity sent is very small and uncertain.

Essential oils.

Essential Oils or Essences.—These are all of vegetable origin, usually of a pale yellow colour; lighter than water, and nearly all liquid at the ordinary temperature. They appear to constitute the odorous and sapid principles of plants. They are slightly soluble in water, perfectly so in alcohol or ether; and they evaporate so readily that their adulteration by any of the fixed oils may be readily detected by a drop of the oil being applied to white paper. The greasy spot will entirely disappear if held before the fire, provided the essential oil be unmixed; but if a fixed oil has been added, the greasy stain will remain. They are obtained chiefly by distillation from various parts of plants, as the wood, bark, leaves, flowers, fruits, and seeds. Some, however, are obtained by expression and other means. The essential oils or essences, as they are frequently called, are arranged by chemists under the three following divisions:—

1*st. Pure Hydrocarbons*, the principal of which are:—*Oil of Turpentine*, yielded by several trees of the Nat. Ord. *Coniferæ*, the principal of which are *Pinus tæda*, Linn., *Pinus palustris*, H. K., and *Abies excelsa*, Poir. It is obtained by making holes in the base of the stem, from which a very large quantity of the fluid substance called turpentine flows and is collected in casks. This is of a light yellow colour, and of the consistency of thin honey; but soon gets hard, by the evaporation of its essential oil. Turpentine, when distilled, yields about 25 per cent. of a thin, colourless essential oil, known as spirit or oil of turpentine, which is chiefly manufactured in this country from turpentine imported from the United States; but a considerable quantity is also sent from America. *Oil of Orange Peel*, from the yellow part (*flavedo*) of the rind, is imported from Sicily, and is used in perfumery. *Oil of Orange Flowers*, or *Oil of Neroli*, from the petals of the flowers, is used in perfumery, and is imported from Italy. *Oil of Orange Leaves*, or *Oil of Petit-grain*, from the leaves and the immature fruit which falls off soon after the flowers, is used in perfumery. It is imported from Italy and France. *Oil of Lemon*, from the yellow portion (*flavedo*) of the peel of the fruit, is used largely in perfumery; and imported principally from Sicily. *Oil of Bergamotte*, from the rind (*flavedo*) of the Bergamotte orange, is used in perfumery, and is imported from Sicily. *Oil of Cloves*, from the spice called cloves, is used in confectionary and perfumery; and is chiefly distilled in England. *Oil of Pimento*, from the spice called Jamaica pepper, allspice, or pimento, is used in perfumery and confectionary; it is chiefly made in England. *Oil of Caraway*, from caraway seeds (the fruit of *Carum Carui*, L., Nat. Ord. *Umbelliferæ*), is distilled chiefly in this country for perfumery and confectionary. *Oil of Camomile*, from the dried flowers of the camomile (*Anthemis nobilis*, L., Nat. Ord. *Compositæ*), is prepared in England; it is used only in medicine. *Oil of Juniper*, from the berries of *Juniperus communis*, L., (Nat. Ord. *Coniferæ*), usually imported from Holland, is used principally in veterinary medicine. *Oil of Thyme*, from the whole plant of *Origanum vulgare*, L. (Nat. Ord. *Labiatæ*), is used in veterinary medicine; and is both made in England and imported from the continental ports. *Oil of Peppermint*, from the whole plant of *Mentha piperita*, L. (Nat. Ord. *Labiatæ*), is used chiefly in confectionary. It is imported in considerable quantities from the United States and from the European ports; but the best is that manufactured in England, at Mitcham, in Surrey, where the cultivation of plants yielding essential oils is extensively carried on; and the distillation of the oils carried to so high a degree of perfection, that the prices realized are often nearly double that of the foreign ones. *Attar*, or *Otto of Roses*, is procured from the leaves of the rose (*Rosa centifolia*, L., Nat. Ord. *Rosaceæ*). This most delicate perfume is only made in India and Persia. The chief manufacture is at Ghazipore, on the Ganges, where thousands of acres of roses are cultivated. The petals of the flower are distilled with water, which comes over highly perfumed. This water is then set aside in basins, carefully covered over to prevent impurities being blown in; and each morning the film of oil which has risen to the surface during the cool hours of night is carefully skimmed off with a feather, and placed in small glass bottles. When pure, it is extremely valuable; the present price in this country being about 80s. per ounce. It is too generally adulterated either with the odourless fixed oil of almonds or gingelly, or the sweet-scented oil of *Andropogon calamus-aromaticus*, a grass which yields an abundance of rose-scented essential oil. Sometimes it consists almost entirely of this sophistication; but it is coarse and disagreeable to the practised perfumer, and can easily be detected; besides which, it remains liquid at the ordinary temperature, whereas pure otto of roses is solid at 83°F. The Persian is chiefly received from Turkey, and is generally considered the best. *Oil of Birch* is distilled in Russia from the bark of the common birch (*Betula alba*, L., Nat. Ord. *Betulaceæ*). It has a sweet cedar-like odour, and is used in dressing Russia leather, to which it communicates its peculiar smell. Lately small quantities have been imported for preparing leather in a similar manner.

2*d. Oxidized Essential Oils.*—*Oil of Mint*, distilled from the whole plant of common mint (*Mentha sativa*, L., Nat. Ord. *Labiatæ*), is chiefly made in England; and used only in pharmacy. *Oil of Penny Royal*, distilled from the whole plant of *Mentha Pulegium*, L. (Nat. Ord. *Labiatæ*), is made in England for medicinal purposes. *Oil of Cassia*, distilled from the bark of *Cinnamomum Cassia*, Blume (Nat. Ord. *Lauraceæ*), is manufactured in China, and imported in considerable quantities, usually in chests like those used for tea, each containing four tin canisters filled with the oil. It is used in perfumery. *Oil of Cinnamon*, distilled from cinnamon or

Oils.

the bark of *Cinnamomum zeylanicum*, Nees (Nat. Ord. *Lauraceæ*), possesses, when pure, all the delicious flavour and pungency of the spice, and is used for similar purposes. Small quantities only are imported from Ceylon. It is frequently adulterated with oil of cassia. The essential *Oil of Almonds* is usually distilled from bitter almonds, although it can also be obtained from the sweet varieties quite as easily; but for economy the cake of the former, from which the *fixed* oil has been expressed, is chosen. When first distilled, this oil contains hydrocyanic or prussic acid, and is consequently a dangerous poison; but when purified by mixing with lime, and the proto-chloride of iron, and re-distilling, it becomes quite innocuous. *Oil of Lavander*, distilled from the flowers of *Lavandula vera*, De Cand. (Nat. Ord. *Labiatæ*), is only used in perfumery. The best is made at Mitcham; but considerable quantities are imported from France and Italy. An inferior kind is made from the flowers of *L. spica*, and is known in commerce as oil of spike. *Oil of Rosemary*, distilled from the leaves and flowers of *Rosmarinus officinalis*, L. (Nat. Ord. *Labiatæ*). It resembles oil of lavander, and is chiefly made in England and France. *Oil of Aniseed*, is distilled both from the seeds of *Pimpinella Anisum*, L. (Nat. Ord. *Umbelliferæ*); and from those of *Illicium anisatum*, L. (Nat. Ord. *Magnoliaceæ*). It is imported in the same manner as oil of cassia, in considerable quantities from China; and is used in medicine, perfumery, and the manufacture of liqueurs. The oils distilled from different species of the genus *Andropogon* (Nat. Ord. *Graminaceæ*) are imported from Ceylon, and used in perfumery. *Oil of Citronelle*, from *A. citratum*, De Cand., has a lemon odour. *Oil of Verbena*, from *A. Schœnanthus*, Linn., resembles the perfumed verbena (*Aloysia citriodora*). *Oil of Rose-scented Geranium* (from *A. Calamus-aromaticus*, Royle) is also produced abundantly in India, where the native medical practitioners use it as a rubefacient for rheumatism. It is also used in perfumery, and particularly to adulterate the otto of roses.

3d. Essential Oils containing Sulphur.—This division embraces only a few chemical oils, such as oils of mustard, garlic, horse-radish, and some others of no general importance.

Imports and Exports of Oils in 1857, *with the Current Prices and estimated Value* (*compiled from the Brokers' Circulars*).

Name of Oil.	Imports.	Duty.	Exports.	Average Price.	Estimated value of Imports.
Animal Oils and Fats.					
Seal	2,016,000 galls.	Free.	27,216 galls.	L.0 3 6 per gall.	L.352,800
Whale or train, of various qualities	1,348,200 „	Free.	227,000 „	0 3 9 „	252,787
Sperm whale	1,360,800 „	Free.	1,600 „	0 8 0 „	544,320
Tallow of Oxen and Sheep—					
British colonies	96,498 cwt.	1d. per cwt.	116,300 cwt.	2 0 0 to L.2 15 0 per gall.	2,926,275
Foreign countries	919,811 „	1s. 6d. „			
Lard	140,660 „	Free.	5,316 cwt.	2 10 0 to L.3 3 0 per cwt.	
Lard oil	114,984 galls.	Free.	654 galls.	4 0 0 per gall.	22,997
Horse fat, called usually "mare's oil"	12,360 cwt.	Free.	.....	1 14 0 per cwt.	20,962
Cod, or cod-liver, of all sorts	1,024,884 galls.	Free.	270,600 galls.	0 4 0 per gall.	204,973
Vegetable Oils and Fats.					
Olive	5,715,600 „	Free.	555,158 „	0 4 0 „	1,143,120
Palm	873,000 cwt.	Free.	190,186 cwt.	2 3 0 per cwt.	1,882,950
Cocoa-nut	146,300 „	Free.	1,274 „	2 2 0 „	307,236
Sessamum, or gingelly	42,136 galls.	Free.	.....	0 3 6 per gall.	7,374
Rape	1,131,480 „	Free.	16,816 galls.	0 3 9 „	212,152
Castor	37,379 „	Free.	865 „	0 12 0 „	224,027
Kokum oil	2,380 cwts.	Free.	Nil.	2 0 0 per cwt.	4,760
Oil or spirit of turpentine	71,584 „	Free.	22,784 cwt.	1 13 0 „	120,797
Essential oils of all sorts	253,700	1s. per lb.	97,000 lb.	1 0 0 to L.50 0 0 per lb.	152,034

(T. C. A.)

OISE, a department of France, lying between N. Lat. 49. 4. and 49. 46.; E. Long. 1. 42. and 3. 8.; is bounded on the N. by Somme, E. by Aisne, S. by Seine-et-Marne and Seine-et-Oise, and W. by Eure and Seine Inférieure. Its form is nearly that of a parallelogram; its length from E. to W. is 65 miles, average breadth about 40 miles; area 2244 square miles. The surface is undulating, with a general slope to the S.W., except a narrow strip of land in the N. of the department, which slopes towards the N. A chain of hills traverses it near its northern boundary, and another runs parallel to the left bank of the Oise; but none of the elevations exceed 850 feet above the level of the sea. The principal river is the Oise, from which the department takes its name. It rises near Chimay, in the province of Hainault in Belgium, not far from the French frontier, and flows S.W. through the departments of Nord, Aisne, Oise, and Seine-et-Oise, until it joins the Seine about 12 miles below Paris. Its whole length is 137 miles; and it is navigable as far as Chaunay 75 miles above its confluence with the Seine. It receives from the left the Serre, the Lette, the Aisne, and the Nonette; and from the right none but small streams, of which the most considerable is the Thérain. A small portion of the west of the department is watered by the Epte, a tributary of the Eure; and the S.E. corner is traversed by the Ourcq, which joins the Seine above Paris. The geological formation of the country is in general calcareous; and the soil in many parts fertile, consisting of a stiff clay; but in some places dry sandy tracts occur, which are entirely barren, or nearly so. Most of the land is well fitted for the cultivation of wheat or other kinds of corn; but the higher regions are chiefly used for pasture; and a great part of the country is covered with wood. The climate is not insalubrious, but rather moist, especially during the long winters. The mineral productions are few and of little consequence, except limestone, which is extensively worked. Small quantities of iron of an indifferent quality are also found. The extent of arable land in the department is estimated at about 960,000 acres: of meadow land, 74,000 acres; of vineyards, 6000 acres; of wood, 200,000 acres; of waste land, 37,000 acres. Corn, pulse, potatoes, and beet-root are produced in sufficient abundance to form articles of export; and hemp, flax, fruits for cider, &c., are also raised. The wine produced in Oise is bad; and the number of vineyards is decreasing. Cattle and horses are reared in the department, but not to any great extent; and the greatest amount of attention is de-

voted to the sheep, which are in general of an excellent breed. There are in Oise about 100,000 head of cattle, 60,000 horses, 600,000 sheep, 50,000 pigs, 1500 goats, 2500 mules, and 8000 asses. Manufactures of various kinds are carried on to a large extent. Among the most important is that of beet-root sugar; but there are also manufactured broad cloth, bricks, tiles, pottery, porcelain, leather, cordage, paper, beer, glass, and other articles. The trade is considerable in the produce of the manufacturing industry, and in grain, fruits, cider, and timber. The means of internal communication consist of the three rivers, Oise, Aisne, and Ourcq, navigable in this department for 82 miles; two canals, 21 miles in length; a railway traversing the department for 43 miles; and numerous roads. Oise forms the diocese of the Bishop of Beauvais; includes 4 courts of primary jurisdiction, 2 courts of commerce, 3 communal colleges, and 841 primary schools. It returns three members to the legislative assembly. The capital is Beauvais, and the department is divided into four arrondissements as follows :—

	Cantons.	Communes.	Pop. (1856).
Beauvais	12	216	128,721
Clermont	8	145	89,413
Compiegne	8	149	95,002
Senlis	7	126	82,949
Total	35	636	396,085

OKA, a river of European Russia, rises in the government of Orel, and flows N.E. through those of Tula, Kaluga, Moscow, Riazan, Vladimir, and Nijni-Novgorod. After a course of about 600 miles, it falls into the Volga at the town of Nijni-Novgorod. It is navigable as far as Orel, and is of great commercial importance, as affording an easy means of communication for the produce of the different regions on its banks. The country that it waters is the most fertile portion of the Russian empire, and has an area of 127,000 square miles. It receives numerous tributaries; of which the most important are the Upa, Jizdra, Nara, Moskva, Tzna, and Kliasma.

OKAMANDAL, a small district of British India, in the presidency of Bombay, and province of Guzerat, forming the north-western portion of the peninsula of Kattywar. It is separated from the mainland by a *runn* or salt marsh, extending from the Gulf of Cutch, in a S.W. direction to Mudhe, where it is separated from the sea by a narrow sand-bank, which is altogether covered during high tides. The area of the district is estimated at 334 square miles; and the length of the coast-line is about 75 miles. The north-western extremity forms a bold headland, which is indented on the N. side by the harbour of Beyt, protected by an island of the same name at its mouth. This district, on account of its favourable situation for molesting the commercial navigation of the Indian Ocean, was for a long time a favourite haunt of pirates; but their lawless depredations have been completely put down by the British government. The soil of Okamandal is quite barren; and the only articles of commerce yielded by the district are the *sankh* or conch-shells, which were formerly used as war trumpets by the Rajpoots; but their principal use is now by the Brahmins for religious purposes. The district contains 43 villages, and a population estimated at 12,590.

O'KEEFFE, John, a popular dramatist, was born at Dublin in 1747. Though educated for a painter, he exhibited from an early age a decided passion for the drama. At the age of sixteen he had composed a play; at the age of eighteen he wrote a comedy, which was acted on the stage; and shortly afterwards he became a member of the company of the Smock-alley Theatre, Dublin. His active brain, however, did not find scope enough in the position of a mere player. While performing at the Irish capital, or strolling during the summer through the provinces, he produced several little pieces which met with success on the stage. At length, in 1778, his farce entitled *Tony Lumpkin in Town*, was played with applause at the Haymarket; and the career of a dramatist was opened up to O'Keeffe. Abandoning the profession of an actor, and settling in London in 1781, he commenced, amid an increasing attack of blindness, to support his family by his pen. Comedies and operatic farces followed each other in quick succession, and were variously brought out by Colman of the Haymarket, and Harris of Covent Garden. Their genial and vivacious sentiment, and broad and whimsical humour, atoned for their poverty of incident and want of individual characters; the great majority of them had a long run of success; and many of them were acted over again at the command of Royalty. It was about 1798 that O'Keeffe, then almost blind, ceased to have connection with the stage. The rest of his life was spent under pecuniary embarrassments. An edition of 21 of his plays, which was published in 1798, scarcely paid the expenses; and a small annuity, which he bought in 1800, and two royal pensions, which were respectively conferred upon him in 1803 and 1826, afforded him but an inconsiderable pittance. His death took place at Southampton in 1833. O'Keeffe, during his long life, had produced no fewer than 68 plays. Of these, *Wild Oats*, *The Agreeable Surprise*, *The Poor Soldier*, *The Highland Reel*, and some others, still retain their footing on the stage. (*Recollections of the Life of John O'Keeffe, written by himself*, in 2 vols. London, 1826.)

OKEN, Lorenz. Under this name the great naturalist of the transcendental or deductive school is commonly known; but his real name was "Lorenz Ockenfuss," under which he was baptized at Bohlsbach, Würtemberg, being born in that small Suabian village on the 1st of August 1779. As "Ockenfuss" he was entered at the natural history and medical classes in the university of Würzburg; whence he proceeded to that of Göttingen, where he became a private teacher, and abridged his name to "Oken." As Lorenz Oken, he published, in 1802, his small work entitled *Grundriss der Naturphilosophie, der Theorie der Sinne, und der darauf gegrundeten Classification der Thiere*, 8vo.

This is the first of the series of works which placed Oken at the head of the "natur-philosophie" or physio-philosophical school of Germany. In it he extended to physical science the philosophical principles which Kant had applied to mental and moral science. Oken had, however, in this application, been preceded by Fichte, who, acknowledging that the materials for a universal science had been discovered by Kant, declared that nothing more was needed than a systematic co-ordination of these materials; and this task Fichte undertook in his famous *Doctrine of Science* (Wissenschafts-lehre), the aim of which was to construct *à priori* all knowledge. In this attempt, however, Fichte did little more than indicate the path; it was reserved for Schelling fairly to enter upon it, and for Oken, following him, to explore its mazes yet farther, and to produce a systematic plan of the country so surveyed.

In the *Grundriss der Naturphilosophie* of 1802, Oken sketched the outlines of the scheme he afterwards devoted himself to perfect. The position advanced in that remarkable work, and to which he ever after professed himself to adhere, is this,—"that the animal classes are virtually nothing else than a representation of the sense-organs, and that they must be arranged in accordance with them." Agreeably with this idea, Oken contends that there are only five animal classes :—1. The *Dermatozoa*, or Invertebrata; 2. the *Glossozoa*, or Fishes, as being those animals in which a true tongue makes, for the first time, its appearance; 3. the *Rhinozoa*, or Reptiles, wherein the nose opens for the first time into the mouth and inhales air; 4. the *Otozoa*, or Birds, in which the ear for the first time opens

Oken. externally; and 5. the *Ophthalmozoa*, or mammals, in which all the organs of sense are present and complete, the eyes being movable and covered with two lids.

In 1805 Oken made another characteristic advance in the application of the *à priori* principle, by a book *On Generation* (*Die Zeugung*, Frankf., 8vo), wherein he maintained the proposition "that all organic beings originate from, and consist of, *vesicles* or *cells*. These vesicles, when singly detached and regarded in their original process of production, are the infusorial mass or *protoplasma* (*urschleim*), from whence all larger organisms fashion themselves, or are evolved. Their production is therefore nothing else than a regular agglomeration of infusoria; not, of course, of species already elaborated or perfect; but of mucous vesicles or points in general, which first form themselves by their union or combination into particular species."

This doctrine is strikingly analogous to the generalized results of the ablest microscopical observations on the development of animal and vegetable tissues which have been prosecuted of late years.

One year after the production of this remarkable treatise, Oken advanced another step in the development of his system; and in a volume published in 1806, in which Keiser assisted him, entitled, *Beitrugen zur Vergleichenden Zoologie, Anatomie, und Physiologie*, he demonstrated that the intestines originate from the umbilical vesicle, and that this corresponds to the vitellus or yolk-bag. Caspar Friedrich Wolff had previously proved this fact in the chick;[1] but he did not see its application as evidence of a general law. Oken showed the importance of the discovery as an illustration of his system. In the same work Oken described and re-called attention to the *corpora Wolffiana*, or "primordial kidneys," as they are now termed and recognised. At this period, the enlightened Duke of Weimar and the poet Goethe (who repaid the friendship of his prince by the reflection of his own undying renown), were bringing to perfection the plan of general education for the grand-duchy. The university of Jena, under these auspices, had been rapidly rising to pre-eminence; not through the wealth of its endowments or by any artificial excitement, but through the celebrity of the professors and members, whose noble aspirations were stimulated by the encouraging eye of the prince, and the observant care of his minister for education. Under these auspices had been fostered a Griesbach, Fichte, Shelling, Feuerbach, the two Humboldts, Hufeland, and Schlegel.

The reputation of the young *privat-docent* of Göttingen had reached the ear of Goethe, and in 1807 Oken was invited to fill the office of "Extraordinary Professor of the Medical Sciences" in the university of Jena. He accepted the call, and selected for the subject of his "Inaugural discourse," his ideas on the "Signification of the bones of the skull," based upon a discovery he had made in the previous year. This famous lecture was delivered in the presence of Goethe, as privy-councillor and rector of the university, and was published by the young professor in the same year, with the title, *Ueber die Bedeutung der Schädelknochen, ein Programm beim Antritt der Professur an der Gesammt-Universität zu Jena*, 4to, 1807. Of the relation of this essay to the vertebral theory of the skull, we shall subsequently offer a few remarks.

With regard to the origin of the idea, Oken narrates in his *Isis*, that, walking one autumn-day in 1806, in the Hartz forest, he stumbled upon the blanched skull of a deer, picked up the partially dislocated bones, and, contemplating them for a while, the truth flashed across his mind, and he exclaimed, "It is a vertebral column!" At a meeting of the German naturalists, held at Jena, some years afterwards, Professor Kieser gave an account of Oken's discovery in the presence of the grand-duke, which account is printed in the *Tageblatt*, or "proceedings," of that meeting. The professor states that Oken communicated to him his discovery when journeying in 1806, to the Isle of Wangeroog. On their return to Göttingen, Oken explained his ideas by reference to the skull of a turtle in Kieser's collection, which Oken disarticulated for that purpose with his own hands. "It is with the greatest pleasure," writes Kieser, "that I am able to show here the same skull, after having it thirty years in my collection. The single bones of the skull are marked by Oken's own hand-writing, which may be so easily known." There was a cause, as we shall presently see, for this circumstantial testimony. Oken.

Oken having delivered and printed his *Introductory Lecture* in 1807, informs us, in the heft vii. of his *Isis*, that he presented copies to Goethe and to other members of the grand-duke's government. "Goethe was so pleased with my discovery as to invite me to stay with him during the Easter week of 1808 in his house at Weimar, which invitation I accepted."

The range of Oken's lectures at Jena was a wide one, and they were highly esteemed. They embraced the subjects of natural philosophy, general natural history, zoology, comparative anatomy, the physiology of man, of animals, and of plants. The spirit with which the professor grappled with the vast scope of science is characteristically illustrated in his essay *Ueber das Universum als Fortsetzung des Sinnensystems*, 4to, 1808. In this work he propounds "that organism is none other than a combination of all the universe's activities within a single individual body." This doctrine led him to the conviction "that world and organism are one in kind, and do not stand merely in harmony with each other."

In the same year he published his *Erste Ideen zur Theorie des Lichts, &c.*, in which he advanced the proposition, that "light could be nothing but a polar tension of the ether, evoked by a central body in antagonism with the planets; and that heat was none other than the motion of this ether." Here Oken may be said to have anticipated the doctrine of the "correlation of physical forces."

In 1809, he extended his system to the mineral world, arranging the ores, not according to the metals, but agreeably to their combinations with oxygen, acids, and sulphur. In 1810 Oken summed up his several views on organic and inorganic natures into one compendious system. The first edition of his *Lehrbuch der Naturphilosophie* appeared in that and the following years, in which he sought to bring his several doctrines into mutual connection, and to "show that the mineral, vegetable, and animal kingdoms are not to be arranged arbitrarily in accordance with single and isolated characters, but to be based upon the cardinal organs or anatomical systems, from which a firmly-established number of classes would necessarily be evolved; that each class, moreover, takes its starting point from below, and consequently that all of them pass parallel to each other." That, "as in chemistry, where the combinations follow a definite numerical law, so also in anatomy, the organs—in physiology, the functions—in natural history, the classes, families, and even genera of minerals, plants, and animals—present a similar arithmetical ratio."

Three editions of this extraordinary book have appeared, each more fully elaborated than the former. An epitome of the work will presently be given. In continuing the personal history of the author of the *Naturphilosophie*, we may first mention that, on Goethe's recommendation, Oken was honoured, on the publication of the first edition of the *Lehrbuch* in 1810, with the title of "Hof-rath," or court-councillor. In 1812 he was appointed "ordinary professor of natural sciences" in the university of Jena."

[1] *Theoria Generationis*, 8vo, 1774.

Oken.

In 1816 he commenced the publication of his well-known periodical, entitled *Isis, ein Encyclopädische Zeitschrift, vorzuglich für Naturgeschichte, vergleichende Anatomie und Physiologie*, 4to. In this journal not only appeared essays and notices on the natural sciences, but on other subjects of interest; poetry, and even comments on the politics of other German states, were occasionally admitted. This led to representations and remonstrances from the governments criticized or impugned, and the court of Weimar gave Oken the alternative of suppressing the *Isis*, or of resigning his professorship. He chose the latter. The publication of the *Isis* at Weimar was prohibited. Oken made arrangements for its issue at Rudolstadt, and this continued uninterruptedly until the year 1848.

The independent spirit manifested by Oken excited his courtly enemies to harsher measures. An accusation was preferred against Oken as a member of a forbidden "secret democratic society;" he stood his trial and was acquitted. He thereupon retired for a while into private life, occupying himself with the editorship of the *Isis*, and with his scientific works. Amongst these may be cited the *Lehrbuch der Naturgeschichte*, 1815–1825; his *Handbuch der Naturgeschichte zum Gebrauch beij Vorlesungen*, 1816–1820; and his *Naturgeschichte für Schulen*, 8vo, 1821. In these manuals Oken considered that he had arranged for the first time the genera and species in accordance with the only true or physio-philosophical principles; stating briefly everything of vital importance respecting them; and that it was the first attempt to frame a truly scientific history of nature.

In 1821 Oken promulgated, in his *Isis*, the first idea of the annual general meetings of the German naturalists and medical practitioners, which happy idea was realized in the following year, when the first meeting was held at Leipzig in 1822. They have been continued ever since in Germany; and similar annual scientific gatherings have been adopted in other countries, of which the "British Association for the Advancement of Science" is an instance, avowedly, at its origin, organized after the German or Okenian model. The writer of the present notice attended the German annual meeting at Freiburg in 1838, and heard a fervid extempore address by Oken of upwards of an hour's duration, in which the rare eloquence of the gifted man, and the sympathy and respect of his countrymen for the orator, were strikingly manifested.

In 1828 Oken resumed his original humble duties as "private teacher" in the newly-established university of Munich; and soon afterwards he was appointed "ordinary professor" in the same university. In 1832, on the proposition by the Bavarian government to transfer Oken to a professorship in a provincial university of the state, he resigned his appointments and left the kingdom.

Switzerland has the honour of affording the final place of refuge, with means of an independent pursuit of science, to this philosophic and patriotic naturalist. Oken was appointed in 1833 to the professorship of natural history in the then recently-established university of Zurich. There he continued to reside, fulfilling his professional duties and promoting the progress of his favourite sciences, to the period of his demise, in the seventy-second year of his age.

Oken's philosophy.

In his *Lehrbuch der Naturphilosophie*, of which a translation of the last edition, by A. Tulk, Esq., has been published by the Ray Society, under the title of *Elements of Physio-philosophy*, Oken begins by asserting that philosophy, as the science which embraces the principles of the universe or world, is only a logical conception; but it may conduct to the real conception. Thus the mathematics are principles (or a philosophy) of which the universe is the reality. "The world consists of two parts—one apparent, real, or material; the other non-apparent, ideal, spiritual. Hence there are two divisions of philosophy,—viz., pneumato- and physio-philosophy."

The latter is the subject of this treatise.

Its object is "to show how, and in accordance with what laws, the material took its origin; to portray the first periods of the world's development from nothing; how the elements and heavenly bodies originated; in what method by self-evolution into higher and manifold forms they separated into minerals, became finally organic, and in man attained self-consciousness." Physio-philosophy is, therefore, in fact, the history of creation, a name under which it was taught by the most ancient philosophers,—viz., as "cosmogony."

Oken.

Man, being the crown of nature's development, must comprehend every thing that has preceded him. "In a word, man must represent the whole world in miniature." Hence the laws of spirit are not different from the laws of nature—both are transcripts of each other.

Physio-philosophy, therefore, is more important than pneumato-philosophy, because nature is antecedent to the human spirit.

And the whole of philosophy consists in the demonstration of the parallelism that exists between the activities of nature and of spirit.

But inasmuch as the spiritual existed before the real, and gave it birth, physio-philosophy must commence from the spirit.

It is divided into three parts: the *first*, treating of spirit and its activities; the *second*, of the individual phenomena or things of the world; the *third*, of the continuous operation of spirit in the individual things.

It would be impossible, within the limits of this article, to follow Oken through his extraordinary development of the science he has thus described. Every sentence is a link in the chain of argument, which could not be extracted so as to be intelligible, nor would it endure further condensation. It must suffice to state that he traces, agreeably with his system, the evolutions of every form of being, organic and inorganic, in a regular series, from the simple element to the most complex shapes. "Polarity is the first force which appears in the world." "Galvanism is the principle of life," "the vital force." "The galvanic process," he says, "is one with the vital process." "There is no other vital force than the galvanic polarity." Oken, then, contends that organism is galvanism, residing in a thoroughly *homogeneous mass*. A galvanic pile, pounded into atoms, must become alive. In this manner nature brings forth organic bodies. The basis of electricity is the air; of magnetism, metal; of chemism (the name he gives to the influence that produces chemical combination), salts. The basis of galvanism, in like manner, is the organic mass. Accordingly, whatever is organic is galvanic; whatever is alive is galvanic. Life, organism, galvanism, are one. Life is the vital process; the vital process is an organic or galvanic process. Galvanism is the basis of all the processes of the organic world.

At the creation God created a mass of organisms of no larger size than an infusorial point. Whatever is larger has not been created but developed. "So," says Oken, "the Bible teaches us." God did not make man out of nothing, but took an elemental body then existing, an earth-clod or carbon, moulded it into form, thus making use of water, and breathed into it life,—viz., air, whereby galvanism or the vital process arose."

Organization is produced by the co-operating influence of light and heat. "The ether imparts the substance, the heat the form, the light the life."

The life of an inorganic body is a threefold action of the three terrestrial elements, in which three processes galvanism consists. The *nutrient* process is magnetic, present and entire in every part of the body, and wheresoever it is withdrawn there is death. It operates according to the laws of crystallization. The *digestive* process acts according to the laws of chemism, which is not only the process of liquefaction, but the process of formation or creation of new organic matter. The digestive process converts the inorganic to the organic mass. It is the formation of mucus. The chyle is strictly a mucus. Into mucus the air finally settles down by the process of oxidation, called the *respiratory* process. By this the juices emerge from their state of indifference, by which each point of the juice becomes polar towards every other; all are mutually attracted, all repelled, and thereby a decided circulation-motion is originated.

Every globule of sap or mucus is *per se* indifferent. It has, therefore, a natural affinity for each of the three elements comprehended in the organism. By respiration it is united

Oken. to the element air, by digestion to the element water, by nutrition to the element earth. These three processes constitute the galvanic process. Thus the galvanic circle is complete, and motion is the manifestation of galvanism. The process of motion is synonymous with the galvanic process—this is the vital process.

The distinction between the organic and the inorganic is self-motion. The organic is destroyed so soon as motion disappears in it; the inorganic is destroyed so soon as motion enters it.

The above will serve as an idea of the spirit of the work, and of the author's style and treatment of the most recondite questions. We now return to Oken's essay on the *Signification of the Bones of the Head*, on which, perhaps, his reputation as an original discoverer is best founded.

There nevertheless still prevails confusion, or indistinctness of ideas, in the opinions set forth relative to Oken's claims to, or share in, the discovery of the vertebral nature and arrangement of the bones of the skull.

All Oken's writings are eminently deductive illustrations of a foregone and assumed principle, which, with other philosophers of the transcendental school, he deemed equal to the explanation of all the mysteries of nature.

According to Oken, the head was a repetition of the trunk—a kind of second trunk, with its limbs and other appendages; this sum of his observations and comparisons —few of which he ever gave in detail—ought ever to be borne in mind in comparing the share taken by Oken in homological anatomy with the progress made by other cultivators of that philosophical branch of the science.

The idea of the analogy between the skull, or parts of the skull, and the vertebral column, had been previously propounded and ventilated in their lectures by Autenreith and Kielmeyer, and in the writings of Jean-Pierre Frank. By Oken it was applied chiefly in illustration of the mystical system of Schelling—the *all-in-all* and *all-in-every-part*. From the earliest to the latest of Oken's writings on the subject, "the head is a repetition of the whole trunk with all its systems. The brain is the spinal chord; the cranium is the vertebral column; the mouth is intestine and abdomen; the nose is the lungs and thorax; the jaws are the limbs; and the teeth the claws or nails." Spix, in his folio *Cephalogenesis*, 1818, richly illustrated comparative craniology, but presented the facts under the same transcendental guise; and Cuvier ably availed himself of the extravagancies of these disciples of Schelling to cast ridicule on the whole inquiry into those higher relations of parts to the archetype, which Professor Owen has called "general homologies." "M. Spix," Cuvier writes, "makes this bone, which I call 'posterior frontal,' the 'scapula' of the upper limb of the head; and M. Oken, according to the same mystical language, makes it the 'merry thought' (*fourchette*) of the upper limb of the head; for it must be remarked, that the *Philosophy of Nature*, in pretending to find again in the head all the parts of the trunk, acts so arbitrarily, that each of those who would apply it employ these strange denominations in a different manner." "Cet *humerus de la tête* de M. Oken devient pour M. Spix le *pubis* de cette même tête, ou, pour parler un langage intelligible, un des osselets de l'ouie." [1]

The vertebral theory of the skull had practically disappeared from anatomical science when the labours of Cuvier drew to their close. It needs only to refer to the works of his chief pupils and successors, Milne-Edwards, John Müller (*Physiologie*), Wagner (*Lehrbuch der Zootomie*), or Agassiz (*Poissons Fossiles*), to have sufficient evidence of that fact. In Owen's *Archetype and Homologies of the Vertebrate Skeleton*, the idea of the vertebral structure of the skull was not only revived but worked out for the first time inductively, and the theory rightly stated, as follows:—"The head is not a virtual equivalent of the trunk, but is only a portion, *i.e.*, certain modified segments of the whole body. The jaws are the 'hœmal arches' of the first two segments; they are not limbs of the head."—(P. 176.) Oken.

Vaguely and strangely, however, as Oken had blended the idea with his *à priori* conception of the nature of the head, the chance of appropriating it seems to have overcome the moral sense—the least developed element in the spiritual nature—of Goethe, unless the poet deceived himself.

Comparative osteology had early attracted Goethe's attention. In 1786 he published his essay *Ueber den Zwischenchiefer den des Menschen und der Thiere*, 4to, Jena, showing that the intermaxillary bone existed in man as well as in brutes. Not a word in this essay gives the remotest hint of his having then possessed the idea of the vertebral analogies of the skull.

In 1820 (*Morphologie*, i., 2, p. 250), Goethe first publicly stated that thirty years before the date of that publication he had discovered the secret relationship between the vertebræ and the bones of the head, and that he had always continued to meditate on this subject. The circumstances under which the poet, in 1820, narrates having become inspired with the original idea, are suspiciously analogous to those described by Oken in 1807, as producing the same effect on his mind. A bleached skull is accidentally discovered in both instances; in Oken's it was that of a deer in the Harz Forest; in Goethe's it was that of a sheep picked up on the shores of the Lido, at Venice. Mr Buckle, in his discourse "On the Influence of Women in the Progress of Knowledge"—*Fraser's Magazine*, April 1858, p. 402, states:—"Goethe, strolling in a cemetery near Venice, stumbled upon a skull which was lying before him. Suddenly the idea flashed across his mind that the skull was composed of vertebræ; in other words, that the bony covering of the head was simply an expansion of the bony covering of the spine. This luminous idea was afterwards adopted by Oken and a few other great naturalists in Germany and France, but it was not received in England till ten years ago, when Mr Owen took it up, and in his very remarkable work on the *Homologies of the Vertebrate Skeleton*, showed its meaning and purpose as contributing towards a general scheme of philosophic anatomy." This reproduction of a disparaging statement respecting Oken necessitates the following summary of the facts:—

It may be assumed that Oken, when a private teacher at Göttingen in 1806, knew nothing of this unpublished idea or discovery of Goethe; and that Goethe first became aware that Oken had the idea of the vertebral relations of the skull when he listened to the *Introductory Discourse* in which the young professor, invited by the poet to Jena, selected this very idea for its subject. It is incredible that Oken, had he adopted the idea from, or been aware of an anticipation by, Goethe, should have omitted to acknowlege the source—should not rather have eagerly embraced so appropriate an opportunity of doing graceful homage to the originality and genius of his patron.

The anatomist having lectured for an hour, plainly unconscious of any such anticipation, it seems hardly less incredible that the poet should not have mentioned to the young lecturer his previous conception of the vertebro-cranial theory, and the singular coincidence of the accidental circumstance which he subsequently alleged to have produced that discovery. On the contrary, Goethe permits Oken to publish his famous lecture, with the same unconsciousness of any anticipation as when he delivered it; and Oken, in the same state of belief, transmits a copy to Goethe, who thereupon honours the professor with special marks of atten-

[1] *Ossemens Fossiles*, 4to, 1824, tom. v., pt. ii., pp. 75–85, quoted in an able article in the *Quarterly Review*, vol. xciii., in which the history of the Discoveries of the Archetype and Homologies of the Vertebrate Skeleton is briefly but convincingly discussed, pp. 70–80.

Oken. tion, and an invitation to his house. No hint of any claim of the host is given to the guest; no word of reclamation in any shape appears for some years. In Goethe's *Tag und Jahres Hefte*, he refers to two friends, Riemer and Voigt, as being cognizant in 1807, of his theory. Why did not one or other of these make known to Oken that he had been so anticipated? "I told my friends to keep quiet," writes Goethe in 1825! Spix, in the meanwhile, in 1815, contributes his share to the development of Oken's idea in his *Cephalogenesis*. Ulrich follows in 1816 with his *Schildkrötenschädel;* next appears the contribution, in 1818, by Bojanus, to the vertebral theory of the skull; amplified in the *Paragon* to that anatomist's admirable *Anatome Testudinis Europœæ*, fol., 1821. And now, for the first time in 1818, Bojanus, visiting some friends at Weimar, there hears the rumour that his friend Oken had been anticipated by the great poet. He communicates it to Oken, who, like an honest man, at once published the statement made by Goethe's friends in the *Isis* of that year (see p. 509), offering no reflection on the poet, but restricting himself to a detailed and interesting account of the circumstances under which he himself had been led, independently, to make his discovery, when wandering in 1806 through the Hercynian forest. It was enough for him thus to vindicate his own claims; he abstains from any comment reflecting on Goethe; and maintained the same blameless silence when Goethe ventured for the first time to claim for himself, in 1820, the merit of having entertained the same idea, or made the discovery, thirty years previously. Such an idea may have occurred to him at that time; in 1807 Goethe may have determined to keep silence on the matter, and have permitted Oken to reap undisturbed the honour of the discovery; for the poet must then, at least, have been convinced that the young professor had made it independently. But this generous hypothesis is incompatible with Goethe's later reclamation. In this he not only ascribes the discovery to himself, but writes, "In the year 1807 this theory appeared tumultuously and imperfectly before the public." By "tumultuously" Goethe signifies his recollection of the applause with which Oken's audience received the first announcement of the theory. What is worse, Goethe apathetically permitted, to say the least, some of his worshippers to undermine the moral character of Oken in reference to this cranio-vertebral hypothesis.

In 1836 an anonymous statement appeared in the *Allgemeine Zeitung*, to the effect that Oken had stolen the idea of the vertebral nature of the skull from Goethe. Oken, with German bluntness, replied in the same journal, that his nameless accuser "was a liar and calumniator."[1] The accuser was silent.

The German naturalists held their annual meeting that year at Jena, and there Professor Kieser publicly bore testimony, from personal knowledge, to the circumstances and dates of Oken's discovery. Neither Goethe nor any of his friends had a word to offer on the subject. Yet the poet continued to permit his flatterers from time to time to ascribe to him the merit of the discovery; and again, in 1824, he claimed it for himself, with the contemptuous allusion, above cited, to the *Introductory Lecture* of 1807, but without mentioning Oken's name. Goethe did not dare directly to impute plagiarism to Oken, who thereupon consistently kept silent. At length, in the edition of Hegel's works by Michelet, 8vo, Berlin, 1842, there appeared the following paragraph, p. 567:—"The type-bone is the dorsal vertebra, provided inwards with a hole, and outwards with processes, every bone being only a modification of it. This idea originated with Goethe, who worked it out in a treatise written in 1785, and published it in his *Morphologie*, 1820, p. 162. *Oken, to whom the treatise was communicated, has pretended that the idea was his own property, and has reaped the honour of it.*" This accusation again called out Oken, who thoroughly refuted it in an able, circumstantial, and temperate statement, in heft vii. of the *Isis*, 1847. Goethe's osteological essay of 1785, and the only one he printed in that century, is on a different subject. In the *Morphologie* of 1820–24, Goethe distinctly declares that he had never published his ideas on the vertebral theory of the skull. He could not, therefore, have sent any such essay to Oken before the year 1807. Oken, in reference to his previous endurance of Goethe's pretensions, states, that "being well aware that his fellow-labourers in natural science thoroughly appreciated the true state of the case, he confided in quiet silence in their judgment. Meckel, Spix, Ulrich, Bojanus, Carus, Cuvier, Geoffry St Hilaire, Albers, Straus-Durckheim, Owen, Kieser, and Lichtenstein, had recorded their judgment in his favour and against Goethe. But upon the appearance of the new assault in Michelet's edition of Hegel, he could no longer remain silent." Oken.

A recent biographer of Goethe asks, "why did not Oken make the charge of plagiarism during Goethe's lifetime?"[2] The answer is, that he at no time made such charge. He left Goethe's affirmations for what they were worth, and to produce such effect as they might with the competent historians of science. It was possible that Goethe had stated a truth: he might only have been uncandid and ungenerous. But that did not make Oken the less an original discoverer. Only when he was charged with plagiarism did he enter into the question with the view of honest self-vindication, and that both before and after Goethe's death.

As to the question of the superiority of the deductive over the inductive method in philosophy, as illustrated by the writings of Oken. His bold axiom, that heat is but a mode of motion of light,—and the idea broached in his essay on *Generation* (1805), viz., that "all the parts of higher animals are made up of an aggregate of infusoria or animated globular monads,"—are both of the same order as his proposition of the head being a repetition of the trunk, with its vertebræ and limbs. Science would have profited no more from the one idea without the subsequent experimental discoveries of Oersted and Faraday; or by the other without the microscopical observations of Brown, Schleiden, and Schwann; than from the third notion without the inductive demonstration of the segmental constitution of the skull by Owen.

It is questionable, indeed, whether in either case the discoverers of the true theories were excited to their labours, or in any way influenced, by the *à priori* guesses of Oken; more probable is it that the requisite researches and genuine deductions therefrom, were the results of the correlated fitness of the stage of the science, and the gifts of its true cultivators at such particular stage.

Oken's real claims to the support and gratitude of naturalists rest on his appreciation of the true relations of natural history to intellectual progress, of its superior teachings to the mere utilitarian applications of observed facts, of its intrinsic dignity as a science.

To natural history thus worthily comprehended Lorenz Oken devoted his whole time and energies up to his last illness, which closed his career at Zurich, on the 11th of August 1851. A fine statue of the philosopher, by Drake of Berlin, has been erected to his honour in the university of Jena, where he first publicly taught.

We give a list of Oken's chief works and original essays:

1. Grundriss der Naturphilosophie, der Theorie der *Sinne* und der darauf gegrundeten Classification der Thiere. Frankf. 1802, 8°. 2. Die Zeugung. Frankf. 1805, 8°. 3. Abriss

[1] "Einen Lugner, Verlaumder und Ehrabschneider," *Allg. Zeit.*, June 20. [2] Lewes, *Life and Works of Goethe*, 8vo, 1855, vol. ii., p. 159.

Oken. der Biologie. Göttingen, 1805, 8°. 4. Ueber die Bedeutung der Schädelknochen, ein Programm beim Antritt der *Professur zu Jena*. Frankf. 1807, 4°. 5. Ueber das Universum als Fortsetzung des Sinnensystems. Jena, 1808. 4°. 6. Erste Ideen zur Theorie des Lichts, der Finsterniss, der Farben, und der Wärme. Jena, 1808, 4°. 7. Grundzeichnung des naturlichen Systems der Erze. Jena, 1809, 4°. 8. Ueber den Werth der Naturgeschichte. Jena, 1809, 4°. 9. Lehrbuch der Naturphilosophie. 3 vols. Jena, 1809–11.—Ed. 2, Jena, 1831.—Ed. 3, Zurich, 1843.—(Angl.) *Elements of Physio-philosophy:* Ray Society. 8°. London, 1847. 10. Lehrbuch der Naturgeschichte. Leipz. 1813.—Weimar, 1815, 1825, 8°. fig. 11. Isis. 12. Handbuch der Naturgeschichte zum Gebrauch bey Vorlesungen. Nürnb. 1816–20, 8°. 13. Naturgeschichte fur Schulen. Leipz. 1821, 8°. fig. 14. Esquisse d'un Système d'Anatomie, de Physiologie, et d'Histoire Naturelle. Paris, 1812, 8°. 15. Allgemeine Naturgeschichte. Stuttg. 1833-42, 14 vols. 8°. fig.—*Wiegm.* Arch. 1835, I. p. 7. 16. Idées sur la Classification des Animaux.—Ann. Sc. n. (2e S) XIV. p. 247. 17. Das Thierreich. Stuttg. 1836–38, 4 vols. 8°. Atl. fol. 18. Idee sulla Classificazione filosofica dei tre Regni della Natura.—Il Politecnico, Milano, III. 1840, pp. 8, 28.—Ann. Sc. Nat. ser. 2, XIV. p. 247. 19. Fortpflanzung der Wasserschnecken ohne Paarung.—Isis, 1817, p. 320. 20. Ueber Geschlecht und Gattung.—Isis, 1817, p. 465. 21. Aufenthalt der Meerwürmer und Anatomie von *Arenicola piscatorum*.—Isis, 1817, p. 466, fig. 22. Reisefragen.—Isis, 1817, p. 537. 23. Ueber *Proteus anguinus* und die durchgehenden Naslöcher als Character der Amphibien.—Isis, 1817, p. 641, fig.; 1821, p. 271. 24. Nachtrag über die Bedeutung der Schädelknochen.—Isis, 1817, p. 1204; 1818, p. 510; 1823, pp. 353, 401; 1837, p. 575. 25. Nachtrag über die Entstehung der Därme aus dem Nabelblaschen.—Isis, 1818, p. 59. 26. Bedeutung der Knochen des Crocodillschädels und der Nasenbeine der Vögel.—Isis, 1818, p. 278. 27. Ueber die Farben der Blumen.—Isis, 1818, p. 472. 28. Die Fresswerkzeuge der Insecten entsprechen den Füssen.—Isis, 1818, p. 477, fig. 29. Verzeichniss der entomologischen Literatur von 1790–1800.—Isis, 1818, p. 711. 30. Anatomie von *Thalassema*.—Isis, 1818, p. 878. 31. Bestimmung der gistigen Milbe in Persien (*Rhynchoprion persicum*).—Isis, 1818, p. 1567. 32. Begriff des Muschelbaues.—Isis, 1818, p. 1817. 33. Deutung des Thieres von Stronsa.—Isis, 1818, p. 2099.—Entstehung des ersten Menschen.—Isis, 1819, p. 1117. t. 13. 34. Bein-Philosophie.—Isis, 1819, p. 1528. t. 18. 35. Ueber *Pterodactylus longi-* et *brevirostris*.—Isis, 1819, p. 1788. t. 20. 36. Ueber die Bedeutung des Insecten Leibes.—Isis, 1820, p. 552. 37. Ueber das Athmen der Pricken.—Isis, 1821, III. p. 271. 38. Nachtrag zu *Richter's* Aufsatz über den weiblichen Kuckucksmagen.—Isis, 1823, II. p. 225. 39. Ueber die Sammlung der vergleichenden Anatomie zu Paris. Isis, 1823, Lit. Anz. p. 265. 40. Zahnsystem.—Isis, 1823, p. 274. 41. Bemerkungen uber die Schädel der Saugthiere, Vögel und Lurche.—Isis, 1823, p. 353. 42. Ueber die Schädel der Fische und die Bedeutung des Kiemendeckels.—Isis, 1823, p. 401. t. 14, 15. 43. Ueber das Brust- und Schultergerüst und das Becken der Thiere.—Isis, 1823, p. 441. t. 16, 17. 44. Bemerkungen über die Skelete von Haarthieren.—Isis, 1823, p. 455. 45. Ueber die niederen Thiere in der Pariser Sammlung der vergleichenden Anatomie.—Isis, 1823, p. 457. t. 17. 46. Ueber die Saugthiere in der Zoologischen Sammlung zu Paris.—Isis, 1823, p. 481. t. 17. 47. Ueber die Vögel, Lurche, Fische, Weichthiere, und Kerfe in dieser Sammlung.—Isis, 1823, p. 505. 48. Ueber das Ey und die Zitzen des Schnabelthiers.—Isis, 1823, p. 1427. 49. Rudimens des pieds vers l'anus des Boas.—*Féruss.* Bull. 1826, VII. p. 445. 50. Bau des Bisambeutels.—Isis, 1826, p. 849. t. 6 (*Féruss.* Bull. 1827, X. p. 144). 51. Ueber die Bedeutung der Fœtus-hüllen und die Ursache des ersten Athmens.—Isis, 1827, p. 371. t. 4. 52. Ueber die Bedeutung der Schulter und Muskeln der Schildkröte.—Isis, 1827, p. 456. 53. Ueber das Zahlengesetz in den Wirbeln des Menschen.—Isis, 1829, p. 306. 54. Ueber die Bedeutung der Farren- und Moos-capsel.—Isis, 1829, p. 395. 55. *Cyprinus uranoscopus*, Agass., aus der Isar.—Naturf. in Berl. 1828.—Isis. 1829, IV. p. 414. 56. Ueber die Aufnahme der Naturwissenschaften in die Gymnasien.—Isis, 1829, p. 1225. 57. Entwickelung des Küchelchens im Ey.—Isis, 1830, VI. p. 575. 58. Ueber das Betragen von Proteus.—Isis, 1832, p. 699. 59. Ueber die Richtung des Wurzelchens u. das Winden des Steugels.—Isis, 1834, p. 804. 60. Ueber *Lepidosiren*.—Isis, 1838, p. 347; 1839, p. 607; 1840, p. 467; 1843, p. 441. 61. Ueber den Steinbruch von Œningen.—Isis 1840, p. 282.—*L. u. Br.* N. Jahrb. 1843, p. 230. 62. Ueber das Perlboot (*Nautilus Pompilius*, L).—Isis, 1835, p. 1. 63. Ueber die Schädelwirbel.—Isis, 1847. 64. Beitrage zur vergleichenden Zoologie, Anatomie und Physiologie.—Bamb. u. Würzb. 1806; 1807, 2 vols. 4°. fig.—Isis, 1818, I. p. 59, von Oken u. Kieser. (R. O.)

Okhotsk || Oldcastle.

OKHOTSK, a town and province of Eastern Siberia, in the district of Yakutsk. The province consists of a narrow strip of country, along the shore of the sea of Okhotsk, about 1000 miles in length, and varying from 80 to 200 in breadth. It is traversed through its whole extent by the Stanovoi Mountains, which run along the sea coast, and send down a few small streams to the sea. Of these the chief is the Okhota. The climate is very severe; but there are some tracts of pasture-ground and clumps of trees. The rein-deer and the dog are the only tame animals; and furs and timber are the only articles of produce. Fish is obtained along the coasts; and shoals of small whales are occasionally met with. The district is used as a penal settlement for the most incorrigible criminals, with whom and their descendants it is for the most part peopled. Pop. about 7000. The town of Okhotsk stands at the mouth of the Okhota. N. Lat. 59. 21., E. Long. 142. 45. It consists of a collection of ill-built and irregularly arranged log-houses; and has a government house, hospital, church, storehouses, &c. It is the principal station of the Russo-American trading company, who convey furs hither from America, and hence to Kiachta, to exchange for Chinese goods. Pop. 957.

Okhotsk, *Sea of*, an inlet of the North Pacific Ocean, between Kamtschatka and Siberia, extending from N. Lat. 50. to 60., E. Long. 137. to 155. From its N. E. extremity the gulfs of Ijighinsk and Perjinsk stretch into the land. Its depth is generally great, and there are few islands. Near the coast it is frozen for 6 months of the year.

OLAND, or Oeland, an island in the Baltic, belonging to Sweden, included in the lan of Kalmar, and separated from the mainland by the Kalmar Sound, which varies from 3 to 15 miles in breadth. Length 85 miles; average breadth 8; area 608 square miles. The western shores are low; those to the east high and steep; and the prevalent formation throughout the island is limestone. To the north are a few small lakes; but no considerable streams anywhere occur. The soil, though scanty, is fertile; and a great part of the surface is covered with fine forests. Cattle and sheep are extensively reared; and deer, wild boars, and other game abound. Öland is famous for its breed of ponies of very small size. The weaving of cloth is carried on, and furnishes an article of export trade. The island contains several villages, of which Borgholm the capital, on the west coast, is the chief. The people are extensively employed in fishing and navigation; and there is an alum mine, the most important in the kingdom, which employs about 300 hands. Pop. 33,000.

OLDCASTLE, Sir John, commonly called "The good Lord Cobham," was born in the fourteenth century, during the reign of Edward III. He obtained his peerage by marrying the heiress of Lord Cobham, who had distinguished himself during the reign of Richard II. for his opposition to the tyranny of that monarch. He commanded an English army in France during the reign of Henry IV. where he displayed great military skill. Oldcastle had, from the outset of his career, set himself with great patriotism and independence to oppose the political and ecclesiastical corruptions of his time. Being a man of fine natural talents, and having a passionate thirst for knowledge, he turned his attention to the doctrines of John Wycliffe; and after examining them with great care, declared his adherence to the cause of the reformers. He collected and transcribed the works of Wycliffe for circula-

Oldcastle ‖ Oldenburg.

tion among the people, and sent preachers of reform into various parts of the country. The cause made great progress, and the growth of heresy was attributed to this nobleman's influence. Henry V. had a partiality for the good lord, and tried to reclaim him by expostulation. "Next to God," said his lordship, "I profess obedience to my king; but as to the spiritual dominion of the Pope, I could never see upon what foundation it was claimed, nor can I pay him any obedience." The king turned away in displeasure, and left the heretic to the tender mercies of the Church. Escaping from the tower where he had been imprisoned as a heretic, he sought refuge in Wales. In 1414 the clergy got up a report of an imaginary conspiracy of the Lollards, with Lord Cobham at their head, for the destruction of the king. A bill of attainder was passed against him; 1000 merks were set upon his head; and perpetual exemption from taxes was promised to any town that should secure him. After an exile of four years in Wales he was at length seized, carried to London, and executed in St Giles' Field in the most cruel and barbarous manner. Johan Bale tells us in his *Brefe Chronycle* of the examination and death of this nobleman: "Than was he hanged up there by the myddle in cheanes of yron, and so consumed a lyve in the fyre, praysynge the name of God so longe as his lyfe lasted" (p. 96). Thus died in 1418 one of the ablest and most brilliant men of his day, who, according to his biographers, was qualified to shine alike in the cabinet, the field, and the court. As a writer Lord Cobham is known by a piece entitled *Twelve Conclusions Addressed to the Parliament of England.* He thus stands distinguished as the first martyr and the first author among the nobility of England. (See *Lives of Wycliffe and his Disciples*, by William Gilpin, 1765.) Capgrave, in his *Chronicle of England* (edited by the Rev. F. C. Hingeston, London, 1858), gives a tolerably minute account of the career of Oldcastle; but with a strong prejudice against him and all Lollards. The priestly chronicler remarks of his lordship: "A strong man in bataile he was, but a grete heretik, and a gret enmye to the Cherch" (p. 304).

OLDCASTLE, a market-town of Ireland, county of Meath, 20 miles N.W. of Trim, and 52 N.W. of Dublin. It has three churches, a market-house, savings-bank, dispensary, school, and poorhouse. There are here lime-quarries, and extensive flour-mills; and an active trade is carried on in yarn. Pop. 1072.

OLDENBURG, Grand Duchy of, one of the states of the German Confederation, consists of three parts, separated from one another by other states. The duchy of Oldenburg properly so called, is bounded on the N. by the German Ocean, E. by Hanover and the territory of Bremen, S. and W. by Hanover; and lies between N. Lat. 52. 50. and 53. 44., and E. Long. 7. 40. and 8. 45. The principality of Lübeck or Eutin is bounded by the duchy of Holstein, the territory of the free city Lübeck, and the Baltic. The principality of Birkenfeld, which forms the third portion of Oldenburg, lies in Southern Germany; and is bounded N. and W. by Rhenish Prussia, S. and E. by Coburg and Hesse-Homburg. Total area, 2433 square miles. The surface of Oldenburg proper is level throughout, as it forms part of the great plain of Northern Germany. Its uniformity is only here and there broken by low sand-hills, such as the Osenberge, between the towns of Oldenburg and Delmenhorst. The land on the coasts of the North Sea and on the banks of the Weser and Jahde is low, rich, and marshy; and is protected by embankments from the incursion of the water. The inland regions consist of moors and heaths. The sea-coast is lined with extensive sand-banks, called *Watten.* The principality of Lübeck is also for the most part flat and barren; but near the sea there are some rich and fertile districts. Birkenfeld is a rocky and mountainous region, with numerous valleys of no great extent. The duchy of Oldenburg is washed by the German Ocean, which forms two gulfs, those of Jahde and Weser, at the mouths of the rivers of the same names; the principality of Lübeck is washed by the Baltic. The principal rivers in Oldenburg are the Weser, which forms its boundary on the side of Bremen and Hanover, and receives the Hunte with its tributary the Lethe, and the Ochtum with the Delme; the Hase and the Leda in the S., which join the Ems; and the Jahde, a small river near the coast. In the principality of Lübeck the Trave, a navigable river, and the Schwentine, both flow into the Baltic. In Birkenfeld the Nahe, an affluent of the Rhine, takes its origin. In Oldenburg and Lübeck there are numerous lakes, some of them of considerable size, but in Birkenfeld there are none. The most important in the duchy proper are the Zwischenahner-Meer, the Great and Little Bullenmeer, while Lübeck contains the Plöner-See, Eutiner-See, Keller-See, &c. The climate is temperate, but damp and foggy on account of the vicinity of the sea. Oldenburg

Agricultural and pastoral employments are extensively practised in Oldenburg. In the marshy land the principal crops raised are wheat, barley, oats, rape-seed, beans, and peas; in the sandy districts, barley, oats, potatoes, hops, flax, hemp, and tobacco, are raised; while in both kinds of land rye is produced, but not enough to supply the inhabitants. In Lübeck the soil is good, and the same crops are cultivated as in the duchy; in Birkenfeld, the stony nature of the ground prevents the raising of much corn, but potatoes, flax, &c., are produced. The whole amount of corn produced in the grand duchy is estimated at more than 3,000,000 bushels. Forests occur chiefly in the principality of Birkenfeld; there is little wood in Lübeck or in the alluvial tracts of Oldenburg, but part of the moorland region is covered with it. The rearing of cattle is carried on chiefly in Oldenburg proper and in the principality of Lübeck; the horses are remarkable for their strength, and the oxen are of good breed. The whole grand duchy contained in 1853–4, 38,193 horses, 198,823 head of cattle, 293,985 sheep, 86,488 swine, and 9905 goats. Fowls are also numerous, and bees are very generally kept. Mining operations are carried on in Birkenfeld only, and these principally in iron, for which there is a furnace, producing on an average about 500 tons yearly. Copper, lead, zinc, and precious stones, are also found in this principality. Manufactures are not extensively carried on in Oldenburg. Yarn-spinning, linen-weaving, and the making of woollen stockings, are the principal branches in which the people are employed. At Varel, the principal manufacturing place in the country, there are cotton factories; and the duchy also contains many breweries, distilleries, meal, oil, and paper mills, saw-mills, &c. Shipbuilding and navigation afford the means of subsistence to many of the inhabitants; and the trade of Oldenburg is of much more importance than the manufacturing industry. The exports consist of corn, cattle, horses, butter, cheese, bacon, hides, leather, yarn, linen, stockings, &c.; while the principal imports are wines, fruits, salt, woollen and silken stuffs, hardware, pottery, &c. The number of vessels that entered and cleared at the ports of Oldenburg in 1856, with their tonnage, was as follows:—

Vessels belonging to	Entered.		Cleared.	
	No.	Tons.	No.	Tons.
Oldenburg	5072	82,764	4565	77,221
Other countries	2397	68,622	2182	66,763
Total	7469	151,386	6747	143,984

Oldenburg has no railways, but lines of telegraph extend from the town of Oldenburg to Elsfleth and to Bremen.

The government of Oldenburg is a limited monarchy.

Oldenburg.

The office of grand duke is hereditary in the male line, and each prince on his accession has to take an oath that he will preserve the constitution inviolate, and rule according to the laws. According to the constitution of 1848, amended in 1852, there is a Diet in a single chamber, composed of members elected by the people. The people appoint electors, one for every 300 inhabitants; and these again elect the delegates to the Diet, of which there is one for every 6000 inhabitants. The number composing the Diet is at present forty-seven. Every citizen of twenty-five years old and upwards has a vote for an elector, and is eligible as an elector and as a member of the Diet. The public receipts and expenditure for 1857 each amounted to L.71,970, and the debt at the end of 1856 was L.652,000. There is no established church in Oldenburg, but the grand duke and the majority of the people belong to the Lutheran body. The duchy contains also a considerable number of Roman Catholics, and a small proportion of Jews. The educational interests of the country are pretty well attended to, but the scarcity of villages, and the way in which the dwellings are scattered throughout the country, especially in the moorland regions, render it impossible to establish a number of schools sufficient for the population. There are in the entire state 4 gymnasia, 4 higher burgh schools, 2 normal schools, a military school, a school of navigation, and other superior and middle schools. The whole number of elementary schools in the grand duchy was (in 1855) 547, with 773 teachers, and 44,879 pupils. The judicial establishment of Oldenburg consists of an upper court of appeal at Oldenburg, courts of chancery in the duchy of Oldenburg and principality of Lübeck, a senate of justice in Birkenfeld, and several inferior courts. The people of Oldenburg are distinguished for order, courage, loyalty, patriotism, hospitality, and benevolence. The ducal family of Oldenburg is of very ancient origin, being descended from Wittekind, a Saxon chieftain, who submitted to Charlemagne in 785. The title of Count of Oldenburg was first assumed by Christian I. in 1156, after he had erected the castle of Oldenburg. In 1232 the county became independent of the empire, and towards the end of the century Count Otto, a younger brother of Christian III. of Oldenburg, obtained by purchase the lordship of Delmenhorst; but the two families were afterwards united by marriage under Dietrich the Lucky. His eldest son, Christian, became King of Denmark, Norway, and Sweden, and Duke of Schleswig and Holstein; while from the younger son, Gerhard, the dukes of Oldenburg are descended. His successors enlarged their territory by the addition of Jever in 1575, and of Kniphausen during the Thirty Years' War. In 1667 the ducal family became extinct, and Oldenburg come into the possession of Denmark; under which kingdom it remained till 1773, when Christian VII. of Denmark transferred it to the elder branch of the Gottorp line in the person of the grand prince Paul, afterwards Emperor of Russia, as a compensation for the claim of the House of Holstein-Gottorp to Schleswig and Holstein. The new possessor of Oldenburg gave it over to the head of the younger branch of the same house, Frederick Augustus, the Prince and Bishop of Lübeck; and in 1777 Oldenburg was raised by the Emperor Joseph II. to the rank of a duchy. In 1810 the duchy was conquered by Napoleon I. and made a French department, but in 1813 it was restored to the ancient ducal family; and at the Congress of Vienna, the principality of Birkenfeld was ceded to it by Prussia. The title of grand duke was first assumed by Duke Augustus in 1829. The lordship of Kniphausen, which had been since 1825 under the supremacy of Oldenburg, became a part of the grand duchy in 1854. The capital of Oldenburg is the town of the same name, and the divisions of the grand duchy are as follows:—

	Bailiwicks.	Parishes.	Pop. in 1855.
I. Duchy of Oldenburg	28	108	232,950
1. Circle of Oldenburg	4	13	42,593
2. „ Nuenburg	4	9	36,891
3. „ Ovelgönne	5	18	30,419
4. „ Delmenhorst	4	15	34,976
5. „ Vechta	3	14	33,191
6. „ Kloppenburg	3	15	31,786
7. „ Jever	5	24	23,094
II. Principality of Lübeck	3	14	21,684
III. „ Birkenfeld	3	22	32,529
Total grand duchy	34	144	287,163

Oldenburg ‖ Oldham.

OLDENBURG, the capital of the above grand duchy, is a well built though dull town, in a flat country, on the banks of the Hunte, 24 miles W.N.W of Bremen. The castle, where the grand duke resides, is a handsome freestone building, surrounded by beautiful pleasure-grounds. Here also are a palace for the princes, government offices, a barracks, which is a large and imposing edifice, and two theatres. The old church of St Lambert, the most remarkable of the three churches in Oldenburg, has a vault containing the tombs of the ducal family. For the intellectual culture of the inhabitants Oldenburg has many advantages: besides military, normal, and grammar schools, there are a collection of antiquities, a gallery of paintings, and a public library of 50,000 volumes. Sugar refineries, soap-works, breweries, distilleries, &c., are the principal manufactories; and timber, wool, &c., the chief articles of trade. The date of the foundation of the town is not known; but in 1155 it was first fortified as it still remains. Pop. (1852) 9526.

OLDENBURG, Henry, was born about 1626 in the duchy of Bremen in Lower Saxony. He came to London in 1653, where he held the office of consul for the town of Bremen for nearly two years. Being discharged from that employment, he was appointed tutor to Lord Henry O'Bryan, an Irish nobleman, whom he attended to the university of Oxford, where he was admitted to study in the Bodleian Library in the beginning of the year 1656. He was afterwards tutor to Lord William Cavendish, and gained the friendship of Milton the poet. During his residence at Oxford he became acquainted with the founders of the Royal Society, and was chosen assistant to Dr Wilkins, the secretary to that body. He applied himself with extraordinary diligence to the business of his office, and in the year 1664 began the publication of the *Philosophical Transactions*, which he continued to No. xxxvi., 25th June 1677. After this the publication was discontinued till the January following, when it was again resumed by his successor, Nehemiah Grew, who carried it on till the end of February 1678. Oldenburg died at Charleton, in Kent, in August 1678. In addition to a few short papers on medical and other subjects published in the *Transactions*, Oldenburg translated several works into English from the French and Latin, under the anagram *Grubendol*.

OLDHAM, an ancient parochial chapelry and market-town, and modern municipal and parliamentary borough, is situated in the hundred of Salford, in the county of Lancaster, distant 7 miles N.E. from Manchester, and 186 miles N.N.W. from London. In the neighbouring hills are the sources of the rivers Medlock and Irk, which pass through the town, and supply moving power to many of the mills.

Oldham is built upon an eminence, and is difficult of access by highways. It has no canal, nor was there any railway accommodation till the year 1842, when a branch was made from the Manchester and Leeds line; this is a great advantage to the district, although its utility is impaired by a steep incline of 1 in 26. Notwithstanding these drawbacks, trade has rapidly extended, a fact which may be accounted for by the existence of vast fields of coal beneath and near the town.

Oldham. For a long period Oldham has been distinguished for the manufacture of hats, a distinction which it maintained till the early part of the present century, when the use of silk instead of beaver considerably diminished the demand, and induced many of the work-people to seek employment in other branches. As little capital is required for the production of silk hats, the trade is now largely distributed over the country. A few extensive establishments still exist here, one of which obtained the highest prize in this department at the Great Exhibition of 1851.

Another important branch of industry is the iron trade, the growth of which has greatly contributed to the prosperity of the place, there being several large works giving employment to upwards of 4000 persons. The principal one, that of Platt Brothers and Co., in which 3000 men and boys find constant occupation, and receive L.130,000 per annum in wages.

Cotton manufacture is the staple trade, there being within the borough, in 1856, 96 mills, with steam-engines of 3400 horse-power, and employing 7906 men and boys, and 8635 women and girls, or a total of 16,541 hands.

Oldham was incorporated in 1849, and is governed by a mayor, 8 aldermen, and 24 councillors. Formerly its sanitary condition was exceedingly defective, the streets ill paved, and the supply of water scanty. Improvements are going on rapidly, and since the water-works have been purchased by the corporation, an increased quantity equal to a million and a half of gallons daily has been secured, which will be sufficient to meet the growing wants of the town for many years to come.

For educational purposes many private schools exist; there is also a most efficient blue-coat school for the instruction and support of 120 orphan boys, endowed by Thomas Henshaw, an opulent hat-manufacturer, who, in 1808, bequeathed for the purpose L.40,000. At his death, in 1810, his heirs filed a bill in chancery, praying that the will might be set aside on the ground of the alleged insanity of the testator. This led to protracted litigation, which terminated in favour of the school. During this time the property bequeathed had accumulated to upwards of L.100,000. By local subscriptions a handsome and capacious building was erected, where, since 1834, nearly 700 orphan boys have enjoyed the comforts of home, and received a substantial English education; many of whom are now filling respectable positions in society. There are several mechanics' institutions; the principal one, the Lyceum, a large and beautiful structure erected at a cost of L.6000, and opened in July 1856, is supported mainly by working men. In the evening classes about 450 operatives receive the elements of a sound English education, with French, Latin, and the higher branches of mathematics, great proficiency being often attained, particularly in the latter study. There are also several national and British schools, and the Sunday-schools contain 12,500 children.

Amongst the public buildings, besides the blue-coat school and the lyceum, is a handsome town-hall, a capacious working-man's hall, and ample and well-arranged public baths. Parochially Oldham is united to Prestwick. The parish church, dedicated to St Mary, is an imposing modern structure, besides which there are eight other churches, four Independent chapels, two Wesleyan, one Roman Catholic, and a large number of places of worship belonging to different Protestant dissenting communities.

Since the passing of the Reform Act it returns two members to Parliament. The population amounted to 12,024 in 1801; to 16,690 in 1811; to 21,662 in 1821; to 32,381 in 1831; to 42,595 in 1841; and to 52,818 in 1851. The annual value of rateable property in 1692 was L.287; in 1857, L.166,815.

OLDHAM, JOHN, justly styled the "English Juvenal," both from the power and severity of his satires, and from his spirited delineation of contemporary life and manners, was the son of a Nonconformist clergyman, and was born at Shipton near Tedbury, in Gloucestershire, on the 9th August 1653. He was educated at Tedbury school and at Edmund Hall, Oxford, where he distinguished himself in Latin and Greek, and displayed a great love for poetry. Scanty means compelled him to leave college after taking his degree of B.A. in May 1674. Idleness and dependence were peculiarly irksome to the proud young scholar, and in the absence of any definite plan of life, he was glad to secure occupation and independence as usher at the free school of Croydon in Surrey. His first published poem, a Pindaric ode on the death of his close companion, Richard Morwent, belongs to this period, and displays not only great power of illustration, but also a subtle tenderness of feeling peculiarly interesting and suggestive when contrasted with the strong satirical vehemence of his subsequent compositions. He endeavoured to lighten the thankless task of "beating Greek and Latin for his life," as he calls it, by secret attention to the muses. Some of his pieces having found their way in manuscript to the literary haunts of the London wits, drew upon their author the attention of such grand personages as Rochester, Dorset, and Sedley. These lettered nobles visited the poor scholar at Croydon, but no immediate consequences followed. In 1678 he became tutor in the family of Judge Thurland, at Reigate, where he remained till 1680. It was about this period he composed those celebrated *Satires upon the Jesuits*, which, appearing in 1679, during the terrible episode of the Popish plot, met with signal success, and at once secured for their author a great reputation. In boldness and bitterness, in strong rage and fierce rancour, no Protestant writer of that feverish time can be compared for a moment with this obscure young Nonconformist. Dryden had more art than Oldham, but did not surpass him in power and depth of invective. On becoming tutor to the son of Sir William Hicks, Oldham made the acquaintance of Dr Richard Lower, who inspired him with a temporary enthusiasm for the study of medicine. After a year's estrangement from his muse, however, the old passion came back upon him, and he resolved no longer to prove inconstant to his first love. Having escaped from the bondage of tuition, Oldham settled in the metropolis, where he gained the acquaintance of the choicest spirits of the time. Dryden contracted the strongest attachment to the young satirist, and recognised in him a genius kindred to his own. Oldham just shared enough in the gaiety and dissipation of the town, to enable him, with fresh energy, to lash its vices and expose its vanities. He was not to be bribed or corrupted from his vocation. He declined the office of private chaplain to the household of the Earl of Kingston, but that generous nobleman, who seems to have had a sincere regard for the proud and manly satirist, prevailed upon him to become his guest at Holmes-Pierpont, in Nottinghamshire. This seclusion the poet did not long enjoy. His constitution was naturally consumptive, and an attack of small-pox put an end to his days on the 9th December 1683, in the thirtieth year of his age. His last piece, *A Sunday thought in Sickness*, is peculiarly touching, from its devotional penitence and humble resignation. The poets of his time wrote enthusiastic tributes to his memory; and distinguished above them all, both for truth and pathos, were the generous lines of Dryden. Oldham's poems, while remarkable for condensed force, rugged vehemence, and striking choice of language, are in general deficient in finish and harmony of versification. This he knew and vindicated. "No one," he says, "would expect that Juvenal, when he is lashing vice and villany, should flow so smoothly as Ovid or Tibullus, when they are describing amours or gallantries."

Oldys ‖ Olearius.

His satires possess a lasting historical value, as a faithful picture of the life and manners of the Restoration; and while the subjects of his invectives are for the most part temporary, the freedom and breadth of handling which they receive inspire them with an abiding interest. For courage and independence—for love of liberty, and scorn of the slavery of patronage—Oldham had no equals among the writers of that servile age. He casts a withering glance of his satirical eye upon "very sparkish dedications," and, reliant on his own genius and honesty of purpose, passes the patron by with a haughty modesty. His works were collected and published in a single volume in 1686; in 2 vols. in 1722. An edition in 2 vols., with a life of the author, edited by Captain Edward Thompson, appeared in 1770; and an admirable edition of Oldham's works, with the omission of a few of his coarser pieces, together with a biography of the poet, appeared in 1854 in the *Annotated Edition of the English Poets*, edited by Robert Bell, London.

OLDYS, WILLIAM, a useful bibliographer, was the natural son of Dr Oldys, chancellor of Lincoln, and was born in 1696. He was an industrious and accurate scholar. Yet as he was a dissolute spendthrift, his whole life, with the exception of ten years, during which he was librarian to the Earl of Oxford, was lent on hire to the London booksellers. His claim to notice rests chiefly on his bibliographical works, such as the *British Librarian*, 8vo, London, 1737. He indeed wrote, among other works, the lives in the *Biographia Britannica* which are marked by the signature G.; and a *Life of Sir Walter Raleigh*, which was prefixed to that author's *History of the World*. But these productions, though rich collections of rare and important facts, are utterly destitute of that sympathetic appreciation of character, which is a necessary element in all real biographies. The death of Oldys took place in 1761. He left behind a manuscript collection of notes on various bibliographical subjects, and a copy of Langbaine's *Lives*, filled with annotations; both of which are preserved in the British Museum.

OLEARIUS, ADAM, a famous German traveller, whose real name was Œlschläger, was born in Aschersleben in Prussian Saxony in the year 1600. After finishing his studies at Leipsic he entered the service of Frederick, Duke of Holstein-Gottorp. There his knowledge of mathematics and geography soon attracted notice. Accordingly, when the duke, intent upon opening a commercial intercourse with India through Russia and Persia, was about to send Crusius, a civilian, and Brugman, a merchant, on two separate embassies to the Russian Czar and the Persian Shah, he appointed Olearius their secretary. The envoys set out on their first embassy in October 1633, and arrived at Moscow in August of the following year. The Czar Michael Federowitz approved and countenanced the enterprise of their master; and they returned to Holstein in April 1635. Their second embassy commenced in October of the same year. Having reached Moscow they embarked on the Moskva, passed from the Moskva into the Oka, from the Oka into the Volga, from the Volga into the Caspian, and, coasting along the western shore of that sea, were cast on shore at Derbend. Then they passed overland by the cities of Ardebil, Sultanieh, and Koom, and arrived at Ispahan in August 1637. At the end of a few months the Shah had made up his mind to open a negotiation with the Duke of Holstein-Gottorp, and the envoys turned their faces homewards. On his return, Olearius set himself to write an account of these expeditions, which was published under the title of *Beschreibung der Muskowitschen und Persischen Reise*, folio, Schleswig, 1647. The work gave much judicious and exact information regarding many subjects previously unknown, and it speedily became popular. It was translated into French by Wicquefort in 1727, and into English by Davies in 1662. The fourth edition of the original appeared in Hamburg in 1696, twenty-five years after the author's death. In addition to other works of lesser importance, Olearius was also the author of a chronicle of Holstein, 4to, Schleswig, 1674.

Oleron ‖ Olivarez.

OLERON (anc. *Uliarus*), an island lying off the W. coast of France, opposite the mouth of the Charente, and included in the department of the Charente-Inferieure. It is about 18 miles in length from N.W. to S.E., and 7 in extreme breadth; and at one part is within a mile of the mainland. The greater part of the island is fertile, but there are also some extensive salt marshes, from which a considerable quantity of salt is made. The chief products are corn, wine, and vegetables. Pop. 17,000. The chief town, Chateau d'Oleron, stands on the S.E. coast, and contains about 3000 inhabitants. This island gives name to a code of maritime laws framed by Richard I. of England, when at Oleron in A.D. 1194. These laws were afterwards received by all the nations of Europe, as the basis of their marine constitutions.

OLINDA, a city of Brazil, province of Pernambuco, 3 miles N. of Recife. It is beautifully situated on a cluster of eminences, and is rather well built. It has a cathedral and other churches, several convents, a bishop's palace, college, hospital, botanic garden, and public library. Pop. 8000.

OLIVA, FERNAN PEREZ DE, the most famous Spanish prose writer of his time, was born at Cordova about 1492. From his boyhood he was remarkable for his unwearied devotion to letters. He studied successively at Salamanca, Alcalá, Paris, and Rome; and, according to his own account, travelled more than 3000 leagues in pursuit of knowledge. But the chief cause of his fame was his successful attempt to develop the power and resources of the Spanish language, by introducing the custom of using it instead of Latin in serious prose compositions. While he was lecturing in the university of Paris on the ethics of Aristotle, he published in his native tongue a didactic dialogue on the *Dignity of Man*. The immediate result of this work, displaying as it did the first specimen of correct and elevated Spanish prose, was to establish its author's reputation, and contribute to his promotion in life. He was successively appointed ethical professor and rector of the university of Salamanca; and would have been elevated to other dignities, had not his death happened prematurely about 1533. The ultimate effect of the dialogue was to induce the prose writers of Spain to use henceforth their own language. Oliva was also the author of other didactic discourses, and several translations from the classical dramatists. His writings were published in 4to, Cordova, 1585, by his nephew, Ambrosio de Morales, and in 2 vols. 12mo, Madrid, 1787. (Ticknor's *History of Spanish Literature*, vol. i., p. 491.)

OLIVA, a town of Spain, province of Valencia, 43 miles N.N.E. of Alicante. It is built in the form of an amphitheatre, on the side of a hill about $1\frac{1}{2}$ mile from the Mediterranean. It has an ancient palace, two parish churches, several convents, and an hospital. Many of the inhabitants are employed in agriculture; and the manufactures are almost confined to hempen and linen cloths. Pop. 5600.

OLIVAREZ, GASPAR GUZMAN, CONDE DUQUE DE, a celebrated Spanish statesman, was descended from an illustrious Castilian family, and was born at Rome about 1587, during his father's embassage to Sextus Quintus. After studying at the university of Salamanca, he received, through the influence of his uncle the Duke of Uceda, the appointment of gentleman of the bed-chamber to the Prince of Asturias, and he immediately commenced the career of a political aspirant. His first design was to gain complete control over the simple boy, his master. He was fast worming himself into favour, when, in 1621, the prince succeeded

Olivenza || Olives.

to the throne of Spain, under the title of Philip IV. He then feigned a reluctance to engage in the new administration. This apparent modesty served alike to conceal his designs, and to raise him in the estimation of the king; and before a few months had passed, he received the title of Duque de San Lucar, as a seal of the royal favour and confidence. The minion now flung aside the mask, and appeared in the character of a selfish and jealous despot. He displaced his uncle from the position of minister, dismissed many of the best servants of the state, and surrounded himself with creatures of his own. If he also disbanded many idle officials, it was mainly to gratify a private distrust; and if he revoked many lavish government grants, it was mainly to defray the extravagant expenses of his ministerial pomp and splendour. At the same time the nation was groaning under the most burdensome imposts, and the consequent decay of agriculture, commerce, and the useful arts. The most disastrous, however, of all the measures of Olivarez, was an attempt to regain by arms the influence which Spain had formerly possessed over the other nations of Europe. Happening in this enterprise to cross the path of the French minister, Cardinal Richelieu, he found himself engaged with an adversary who baffled him at every point, and ultimately effected his overthrow. The cardinal's stratagems involved him in a long and unsuccessful war with the Dutch; the cardinal's forces checked his armies in Germany and Italy; and the cardinal's intrigues fanned the rising flame of insurrection within the Spanish dominions. The national discontents were thus brought to a climax in 1640. The province of Catalonia rebelled, and called in the aid of the French; Portugal threw off the Spanish yoke, and elected the Duke of Braganza its king; and at the end of two years the insurgents had foiled all attempts at suppression, and were steadily increasing in strength. It was at this emergency, in 1643, that the numerous enemies of Olivarez succeeded in supplanting him in the king's favour. The disgraced minister died at Toro in the same year, with the reputation of having brought his country to the verge of ruin.

OLIVENZA, a fortified town of Spain, province of Estremadura, near the left bank of the Guadiana, on the Portuguese frontier, 15 miles S.S.W. of Badajoz. The surrounding country is fertile in corn and wine, and an active trade is carried on in the town. There are several churches and convents, three hospitals, and a poorhouse. Olivenza is strongly fortified, and till 1801 belonged to Portugal. Pop. 6300.

OLIVER, Isaac, an eminent miniature-painter, was born in England in 1556. After studying, it is said, under Nicholas Hilliard and Frederigo Zuccaro, he appeared before the public as a professional artist. At times he painted history, and executed drawings after Parmigiano and other Italian masters. But it was in the field of miniature portrait-painting that his fame was won. His likenesses of Mary Queen of Scots, Queen Elizabeth, Henry Prince of Wales, Sir Philip Sydney, Ben Jonson, and others, were unrivalled for their delicate truthfulness and exquisite finish; and afterwards obtained a place in the celebrated collection of Dr Mead. It was after a miniature of his that the portrait of James I. was painted by Rubens and Vandyck. Isaac Oliver died at his house in Blackfriars in 1617.

Oliver, *Peter*, the eldest son of the preceding, was born in London in 1601. He was instructed in art by his father, and succeeded to his father's place and reputation in miniature portrait-painting. Among other works, he executed a portrait of his wife, which was, in the time of Walpole, in the possession of the Duchess of Portland; and seven historical pieces, which were lately in Queen Caroline's closet in Kensington Palace. His death took place about 1654.

OLIVES, Mount of, a ridge, now called by the Arabs *Jebel-el-Tur*, lying on the E. of Jerusalem, on the other side of the narrow valley of Jehoshaphat. Towards the S., over against the "well of Nehemiah," it sinks down into a lower height, now called by Franks the "Mount of Offence," in allusion to the idolatrous worship established there by Solomon. Near this lies the usual road to Bethany, so often trodden by our Saviour. About a mile towards the N. is another summit, nearly equal in height to the middle one. Beyond the northern summit the ridge sweeps round towards the W., and spreads out into the high level tract N. of the city, which is skirted on the W. and S. by the upper part of the valley of Jehoshaphat. The elevation of the central peak of the Mount of Olives is estimated by Schubert at 2556 Paris feet, or 416 Paris feet above the valley of Jehoshaphat. This considerable ridge derives all its importance from its sacred associations. To the mount whose ascent David "went up, weeping and barefoot," to which our Saviour ofttimes withdrew with his disciples, over which he often passed, and from which he eventually ascended into heaven, belongs a higher degree of sacred and moral interest than is to be found in mere physical magnitude, or than the record connects even with Lebanon, Tabor, or Ararat.

Olivet || Olivier.

OLIVET, Joseph Thoulier d', an elegant writer and accomplished classical scholar, was born at Salins in 1682. Being destined for the church, he entered the Order of Jesus, and studied theology at Rheims, at Dijon, and at Paris. But it was not until he had mingled familiarly in the society of such men as Boileau, Huet, and Rousseau, that his mind caught its fine ardour for classical learning, and his life took its peculiar bent. He soon afterwards resolved to leave the society of the Jesuits: the offer of the important position of tutor to the Prince of Asturias could not induce him to alter his resolution; and he retired to his quiet study in Paris, to live contentedly upon the emoluments of a small benefice. Then began that series of literary publications on the works of Cicero which has associated the name of Olivet with that of the great Roman orator. In 1721 was printed his translation of the *De Natura Deorum*,—a work which was the means of gaining for him an admission into the French Academy. He published his version of the *Orations against Catiline* in 1727; and in 1737 he appeared, along with President Bouhier, as the joint-translator of the *Tusculan Disputations*. In 1740–1742 was given to the public his masterpiece, the edition of the entire works of Cicero, in 9 vols. 4to. A collection of extracts from Cicero, accompanied with a French translation, entitled *Pensées*, and published in folio, 1744, completed his elucidations of his favourite author. Meanwhile the Abbé d'Olivet had been emulating the elegant and severely simple style of the classical historians in his *Histoire de l'Académie Française*, intended for a continuation of Pelisson's History, and published in 2 vols. 4to, 1729. His death took place in 1768.

Olivet was also the author of a grammatical treatise entitled *Remarques sur la Langue Française*, in 12mo, Paris, 1767; and of a translation of the *Philippics* of Demosthenes, printed along with his version of the *Orations against Catiline*. Editions of his several translations from Demosthenes and Cicero appeared in 1766. His edition of Cicero has been very frequently reprinted.

OLIVIER, Guillaume Antoine, a learned French entomologist, was born at Arcs, near Draguignan, in 1756, and took the degree of Doctor of Medicine at Montpellier. His whole life was eagerly devoted to the advancement of natural science. While still a young man, he was drawing up an illustrated account of the Coleoptera for a projected entomological history by Gigot d'Orcy; and he was also engaged in writing a natural history of insects for the *Encyclopédie Méthodique*. After the convulsions of the French revolution had interrupted both these undertak-

Olmutz ‖ Olonetz.

ings, his increasing reputation recommended him to the notice of Roland, minister of the interior, as a fit person to be sent along with Bruguières on a mission to Persia, for the purpose not only of establishing commercial relations with that country, but also of making contributions to natural science. On his return at the end of more than six years, he set himself to write an account of his voyage, and to finish the two works he had left incomplete. His election into the Institute in 1800 stimulated his industry. He published in 1802–7 his *Voyage dans l'Empire Othoman, l'Egypte, et la Perse*, in 3 vols. 4to; he finished in 1808 his *Histoire Naturelle des Coleoptères*, in 6 vols. 4to; and he was engaged in his *Dictionnaire de l'Histoire Naturelle des Insectes de l'Encyclopédie Méthodique*, when the disease manifested itself which caused his death at Lyons in 1814. This last treatise, which had been begun to be printed in 1789, was completed in 1819, in 9 vols. 4to.

Olivier also contributed several articles on his favourite studies to the Memoirs of the Institute and of the Society of Agriculture, and to the *Nouveau Dictionnaire d'Histoire Naturelle applique aux Arts* of Déterville. (For an account of his special services to the cause of natural science, see ENTOMOLOGY.)

OLMUTZ (Morav. *Holomauc*), a city, capital of a circle of the same name, and formerly the capital of Moravia, stands on the River March or Marawa, 40 miles N.N.E. of Brünn. It is strongly fortified, being surrounded by walls and protected by a citadel, and is reckoned one of the strongest places in the Austrian dominions. It is entered by four gates, and is for the most part well built. The cathedral is a fine Gothic edifice, founded about the beginning of the fourteenth century by Wenzel III. of Bohemia. Several of the other churches, of which there are twelve, are handsome buildings, particularly that of St Mauritius, which contains the largest organ in Moravia, and that of St Michael. Among the other public buildings are the town-hall, the archbishop's palace, the former college of the Jesuits (now used as barracks), and the university buildings. The university was removed from Olmutz to Kremsir in consequence of the outbreak in Austria in 1848–50. The university library contains about 50,000 volumes. Among the educational institutions here are an academy of nobles, an archiepiscopal seminary, a gymnasium, and a military school. Olmutz is the seat of judicial and other courts, and various public offices of the circle. There are a maternity hospital, an hospital for the sick, and an orphan hospital. It has manufactures of linen, woollen, and cotton stuffs, leather, earthenware, and vinegar; and carries on an active transit trade, especially in cattle. Olmutz was taken by the Swedes during the Thirty Years' War; but was besieged in vain for seven weeks by Frederick the Great in 1758. Lafayette was confined here in 1794. Pop. (1851), exclusive of the military, 11,406.

OLNEY, a market-town of England, county of Buckingham, on the left bank of the Ouse, which is here crossed by a bridge of four arches, 18 miles E.N.E. of Buckingham. The town is small but neat, and is surrounded by beautiful scenery. It is chiefly celebrated as having been for a lengthened period the residence of the poet Cowper, during which time the Rev. John Newton was curate here. The parish church is a large Gothic edifice, with a spire 185 feet high. There are several almshouses and dissenting places of worship. The inhabitants are employed in lace-making, hosiery, and silk-weaving. Pop. of parish (1851), 2329.

OLONETZ, a government of European Russia, lying between N. Lat. 60. and 64. 30., E. Long. 29. 40. and 42. 20., is bounded on the N. and E. by Archangel, S.E. by Vologda, S. by Novgorod, S.W. by St Petersburg, and W. by Lake Ladoga and Finland. Its length from N.W. to S.E. is 370 miles; breadth, 250 miles; area, 53,875 square miles. The surface is for the most part flat, but in the N.W. there are some hills of no great height, called the Mountains of Olonetz; while in the S. the country is traversed by a ridge that divides the affluents of the Volga from those of the Baltic. The geological formation of the hills is for the most part granitic, covered over with conglomerate and clay-slate, and the tops are densely wooded, while the lower slopes are in many places quite open. The level part of the country consists to a large extent of marshy land, but much of the area is occupied by a rich clayey soil covered with greensward, and the extent of ground under water is very great. Upwards of seven-tenths of the whole area is covered with wood. There are said to be 1998 lakes, and 858 rivers and streams. The principal lakes are Ladoga and Onega, which are described under their proper names. The chief rivers are—the Onega, which flows into the White Sea; the numerous streams, which fall into Lake Onega; the Svir, which joins Lake Onega with Ladoga; and a few tributaries of the Volga in the S. The mineral resources of Olonetz form no small portion of the wealth of the government. Iron ore is obtained on the lakes and marshes, and several mines, richer than those formerly worked, have been recently discovered. Copper mines were formerly worked, but on account of their scanty produce, these have been abandoned. Some traces of gold have been observed, and it is believed to occur at a considerable depth below the surface. Coal is also expected to be obtained in Olonetz. Many kinds of marble, porphyry, granite, and quartz, are found; as well as amethysts, garnets, topazes, and other precious stones. In the marble works of Tewdia, many pieces of stone carving are made, which are remarkable for durability and beauty of workmanship. In this government was obtained the piece of porphyry which was sent by the Emperor Nicholas to France to form the coffin of Napoleon I. The climate is severe, the winter long and intensely cold, while during the short summer the heat is very great. But notwithstanding this inclemency, agriculture is carried on in all parts of the government, though the produce is not sufficient for the domestic wants. Hemp and flax are extensively grown in places where corn would not thrive. But the most valuable part of the vegetable produce is timber, of which there is a great abundance, especially of pines and larches, suitable for the masts of ships. Of the whole area of Olonetz, there are 91,186 acres of meadow land, 692,816 acres of arable land, 237,647 acres of hay, 26,815,715 acres of wood, and 6,505,009 acres of lakes, rivers, and marshes. Cattle are not reared in large numbers, owing to the expense of keeping them during the long and severe winters. Most of the peasants, however, have some horses, cows, and swine; but the total number, compared with the extent of the country, is small. There were in 1849, 53,356 horses, 96,392 horned cattle, 82,438 sheep, 5659 pigs, and 187 goats. Of wild animals, the government contains wolves, bears, elks, reindeer, foxes, &c. Seals are found in the large lakes, and the rivers abound in fish. Few manufactures are carried on, except at Petrozavodsk, the capital, where there is an imperial cannon foundry. Trade also is in a low condition. The raw produce of the country, together with tallow, cast-iron, and cannons, are exported to St Petersburg and Archangel. The inhabitants are almost all Russians, but there are some Finns in the western part, and a few wandering Laplanders. The people of Olonetz belong to the Greek Church, and to the see of the Archbishop of Novgorod. There are in the government 46 educational institutions of various kinds, with 102 teachers, and 2059 scholars. Pop. (1856) 285,945.

Oloron.

OLORON (the ancient *Iluro*), a town of France, capital of a cognominal arrondissement in the department of Basses-Pyrénées, stands on the summit and slope of a hill, on the

Olot ‖ Olympia.

right bank of the Gave d'Ossau, where it unites with the Gave d'Aspe to form the Gave d'Oloron, 15 miles S.W. of Pau. It is the seat of a tribunal of primary instance, and carries on an active trade in wool, sheep-skins, hams, cattle, and timber. The principal manufactures are woollen cloths and yarn, hosiery, leather, paper, and combs. Pop. (1856) 5869.

OLOT, a town of Spain, in the province of Gerona, about 15 miles N.W. of the town of that name, and 85 from Barcelona. It lies on the left bank, and about two leagues from the source of the River Fluvia, on a small plain at the foot of the volcanic hill Montsacopa, and on the north of the small circle formed by that hill and six other extinct volcanoes in the vicinity. In spite of its proximity to the Pyrenees, the climate is remarkably temperate. The houses of the town are built of the light porous trap that abounds, made into a concrete by being mixed with gypsum in large moulds, basaltic stone forming the foundation. The streets are narrow and ill paved, but regular. The parish church, San Estéban, is a spacious and fine edifice, contrasting with the tasteless architecture of the other buildings of the town. There are, besides, seven other churches; one primary school, well endowed, in a building intended for an hospital; a grammar school, a school of design, and six smaller schools; an ex-convent of Carmelites, now a barrack; a workhouse, a good modern theatre, and a small wooden circus for bull-fights. The town is remarkable for its copious supply of water. There are ten fountains within the walls, and outside the city they are very numerous, forming convenient lounging and dining places in summer for the inhabitants. The surrounding country is woody and fertile, producing the cereals, legumes, wine of inferior quality, and oil. Cows and sheep are reared; and there is abundance of small game. The chief industry of the town is the production of coarse woollen and cotton fabrics, now falling into decay, the coarse woollen caps, which formerly constituted an important branch of manufacture, being now little worn. There are manufactures also of linen, paper, and leather to a small extent; and a ribbon factory, remarkable in Spain as being lighted with gas made on the premises, a convenience entirely wanting in the towns of the province. Olot is a very ancient town. There are remains of an aqueduct and bridge of Roman construction. In 1427 it was entirely destroyed by an earthquake. It figured and suffered much in the war of independence, being a strong point, and passed alternately into the hands of French and Spanish, until the latter dismantled the fortifications. In the last civil war it was much coveted, and frequently attacked by the Carlists, but unsuccessfully. Among its remarkable men the celebrated jurist Fontenella may be mentioned. Pop. (1849) 9988.

OLTENITZA. See DANUBE.

OLYMPIA, a town of ancient Elis in Greece, stood at a small distance W. from Pisa, on the right bank of the Alpheus (*Rufia*), in a plain that opened westward towards the Ionian Sea, and was skirted on all other sides by hills. It was chiefly famous for its sacred grove, said to have been inclosed by Hercules, and called by pre-eminence *Altis*, a word which is the Peloponnesian Æolic form of ἄλσος. Many sacred edifices rose up among the planes and wild olive-trees of this grove. By far the most important of these was the Olympieium or Olympium, the temple of Jupiter Olympius, which stood near the southern boundary of the Altis, and faced the east. It was founded by the Eleians in 572 B.C. The spoils which that people had taken in their war against Pisa and the neighbouring cities were devoted to its erection; and after the lapse of nearly a century, it received its last finish from the chisel of Phidias the great sculptor. It was a peripteral hexastyle structure of the Doric order, built of limestone from the adjacent mountains, roofed with slabs of Pentelic marble, occupying a site of 230 feet in length, and 95 in breadth, and rising to the height of 68 feet. Both pediments were enriched with legendary stories in relief: the front pediment was topped by a gilded statue of Victory, and below it, attached to the frieze, hung twenty-one votive bucklers, the offering of the Roman general Mummius. At the two ends of the temple were two brazen gates leading respectively into the two chambers into which the building was divided. The western and backmost chamber was called the *Opisthodomus*. On entering the eastern and front chamber, the spectator advanced straight forward up a double colonnade towards a rich and gorgeous curtain, which intercepted his view. The curtain was drawn aside, and there, on a cedar throne, spangled with inlaid gold, ivory, ebony, and precious stones, and crowded all over with painted and sculptured stories of the gods, appeared the master-work of Phidias, the colossal gold and ivory statue of the Olympian Jove, seated with an image of Victory in his right hand and an eagle-surmounted sceptre in his left, and almost touching the roof with his olive-crowned head. Behind the temple of Jupiter the background of the sacred grove was crowded with other structures. There were the Heræum (the temple of Juno), the great altar of Jupiter, the Metroum (the temple of the Mother of the Gods), the Prytaneium, and the Bouleuterion. There were also altars, porticoes, monuments, and statues peeping out at intervals from among the trees.

Olympiad ‖ Olympias.

Olympia was also famous as the scene of the Olympic games. Close to the eastern wall of the Altis stood the *stadium*, or seat for the judges, a long embankment of earth bent into the form of a horse-shoe, resting its circular extremity on the foot of Mount Cronius, and opening its other extremity to the south. Joining the two ends of the stadium, and forming a continuation, were two rows of stables and other apartments, which, inclining towards each other, ran southward until they made a narrow aperture, and inclosed a space. This space was called *hippaphesis*, from being the starting-place of the horses; and *embolus*, from having an outline like the beak of a ship. The aperture of the embolus led into the *hippodrome* or race-course, which extended for the space of two stadia towards the River Alpheus, and was bounded on the right by a small eminence, and on the left by an artificial embankment.

The information regarding Olympia is chiefly derived from the fifth and sixth books of the *Itinerary* of Pausanias. Of all the edifices that he describes, the temple of Jupiter is the only one whose site can definitely be traced. Much light, however, has been thrown upon the subject by Leake's *Peloponnesiaca*. (See also Mure's *Tour in Greece*, &c., in 2 vols., 8vo, 1838.)

OLYMPIAD. See CHRONOLOGY.

OLYMPIAS, the mother of Alexander the Great, was the daughter of Neoptolemus I., King of Epirus, and became the wife of Philip II., King of Macedonia, about 359 B.C. The numerous amours of her husband soon began to keep her in the torment of jealousy; but it was not until 337 B.C., when he married Cleopatra, the niece of Attalus, that her revengeful and imperious disposition burst forth with remorseless fierceness. Hastening to her native country, she endeavoured to persuade her brother, the King of Epirus, to exact vengeance for her wrongs. Unsuccessful in this attempt, she returned to Macedonia to try more insidious measures. She encouraged her son Alexander to intrigue against his father, and at length, it is said, hired Pausanias to murder her husband. There is even reason for believing that she took up the body of the crucified assassin, placed a crown of gold upon his head, burnt his remains over the tomb of the murdered king, and instituted annual rites in honour of his memory. The accession of Alexander enabled Olympias to give freer vent to her lawless passions. One of her first acts was to put to death her rival Cleopatra, and her rival's infant. Then, by attempting to usurp the chief power in the absence of her

Olympic Games.

son, she involved herself in an inveterate quarrel with the regent Antipater. During the life of Alexander she directed a continued series of recriminations against her adversary, and after the death of Alexander she plotted his overthrow in her retirement in Epirus. At length the demise of Antipater in 319 B.C. left Olympias free to engage in some new enterprise of ambition. Accordingly, in 317 B.C., she took the field in person to support the cause of the new Macedonian regent Polysperchon against Cassander and his allies, and advanced to encounter an army under the princess Eurydice. At the sight of the mother of Alexander, the opposing forces threw down their arms without striking a blow; and the queen celebrated the triumph by butchering in cold blood Eurydice, her husband Arrhidæus, Nicanor the brother of Cassander, and a hundred Macedonian nobles. This was the crowning act of Olympias' long course of vindictive cruelty, and retribution was close at hand. Towards the close of that same year she found herself besieged in Pydna by Cassander; in the spring of 216 B.C. her garrison was driven by famine to a surrender; and, contrary to the stipulations, she was condemned to death. A body of soldiers was sent to execute the sentence in the prison; but the fearless and commanding mien of Philip's wife and Alexander's mother overawed them, and sent them huddling towards the door. The Macedonians whose friends had been murdered by her then rushed in upon her; but she received their strokes without uttering a single cry of weakness, and fell with all the dignity of a queen.

OLYMPIC GAMES, the greatest of the national festivities among the Greeks. They derived their name from Olympia, the place at which they were celebrated. (See OLYMPIA.) Their great antiquity is shown by the mythical accounts that are given of their origin. Hercules, Pelops, and Atreus are severally represented by different legends as the founders. But the first historical fact regarding the Olympic games is their revival in the ninth century B.C. by the conjoint exertions of Iphitus of Elis, Lycurgus of Sparta, and Cleosthenes of Pisa. The festival was then appointed to be held once every four years; the intervals between the periods of celebration were called *Olympiads;* all persons of pure Hellenic blood were invited to contend in friendly contests by the banks of the Alpheus; a general armistice was preserved throughout Greece during the festive days; and the territory of Elis was considered consecrated ground. Great crowds of Greeks from all parts, both at home and in the colonies, were wont to frequent the Olympic games—some for the purpose of taking part in them or of seeing them, but many more for other purposes. Friends came to meet friends; traders to find customers; magnates to be the θεωροί or representatives of their different states; painters and other artists to exhibit their works; and literary men to publish their books by reading them to the multitude. All women were forbidden, on pain of death, to be present, or even to cross the Alpheus. At first the inhabitants of Pisa superintended the games; but after the conquest of that city by the Eleans, the conquerors claimed the management, and chose the *hellanodicæ* or judges out of their own state. (See HELLANODICÆ.) How the competitors were trained previously, what exercises were the subjects of the competition, what honours were lavished upon the victors, and what effect the Olympic gatherings had upon the social prosperity of the Greeks, have all been fully noticed in the article GAMES. The Olympic games continued to be celebrated after the Greeks had been subjected to the yoke of Rome. Roman citizens took part in them; and Roman emperors expended large sums of money in celebrating them. At length, in 394 A.D., under the reign of the Emperor Theodosius, after they had existed for more than a thousand years, and had outlived many famous kingdoms and republics, they were finally abolished.

Olympiodorus ‖ Olympus.

OLYMPIODORUS, a Neo-Platonic philosopher of Alexandria, flourished in the former half of the sixth century, immediately before the Pagan schools were closed by the edict of Justinian. He delivered comments upon the *Gorgias*, *Philebus*, *Phædo*, and *Alcibiades* I. of Plato. These scholia evince extensive learning, and a special acquaintance with Iamblichus, Syrianus, Damascius, and other Neo-Platonists. They also contain many striking and clearly apprehended modifications of the doctrine of the Alexandrian school. The most important of these is the distinction drawn between religion and philosophy. According to Olympiodorus, religion teaches by allegories, philosophy by clear and distinct thoughts; the former presents an inert and barren symbol to the imagination, the latter fixes a living and procreative idea in the mind. It is therefore necessary that philosophy should strip off the allegorical dress of religious doctrines, and expose the naked truth within. Accordingly he gives a metaphysical and moral interpretation to the principal classical myths. Another interesting feature in the scholia of Olympiodorus is his occasional treatment of the great questions in psychology and moral science. He holds that reason is the supreme element in the soul, and has a right to rule over sensibility and will, the two other elements. This doctrine leads him to maintain that the moral nature of man is in its best state only when it is wholly subject to reason, and that virtue is nothing else than wisdom. The human soul, thus governed by a principle more elevated than its fellows, he assumes to be the model for all political communities, and infers, like his master Plato, that an aristocratic government is the best.

The scholia of Olympiodorus on the above-mentioned dialogues of Plato have not come down to us entire, but only in notes of his lectures taken by his students. Some of the scholia on the *Phædo* were published by Forster, Oxford, 1745; those on the *Gorgias* by Routh, Oxford, 1785; those on the *Alcibiades* I. by Creuzer, Frankfort, 1821; and those on the *Philebus*, by Stallbaum, Leipsic, 1826. Olympiodorus is also the author of a Life of Plato, which has been published by Etwall, London, 1771; and by Fischer, Leipsic, 1783; in both cases along with some of the Platonic dialogues. A philosophical analysis and a bibliographical summary of his works are given in Cousin's *Fragments Philosophiques*, 4th edition, 12mo, Paris, 1847.

OLYMPUS, a lofty mountain in Greece, stands on the frontier line between Thessaly and Macedonia. Its position and aspect are worthy of its ancient fame; and it might still be called, as it was by the classical poets, "the leafy," "the shady," "the many-ridged," and "the snowy" Olympus. It rises boldly up from the pleasant vale of Tempe on the south, and the Macedonian plains on the north, to the height of 9754 feet, towering above all the neighbouring summits, and looking eastward over the Thermaic Gulf to the distant peaks of Mount Athos. Forests of pine, oak, chestnut, beech, and other trees, sweep along its base and climb its sides; its rocky masses farther up are cleft by numerous yawning ravines; and its broad summit rises against the clear sky covered with a sheet of sparkling snow. Such lofty grandeur rendered Olympus a worthy habitation for the deities of the early Greeks. There Jove sat when he filled the sky with his thunder-clouds, and scattered his lightning-shafts over the world. There, too, in a palace reared by Vulcan, he summoned the gods to council or to banquet. From this spot also he was wont to pass out into the exterior sphere of the universe through an opening which was made in the metallic dome of the sky, and which had a thick cloud for a door. Becoming thus, in course of time, identified with the abode of the gods, the

Olynthus ‖ Omar.

word Olympus was afterwards used as a synonyme for heaven.

There were several other mountains called Olympus, the most important of which were the hill in Elis near Olympia, the range in Mysia extending eastward along the boundary line between Phrygia and Bithynia, and the chain of heights in the island of Cyprus.

OLYNTHUS, a town of Chalcidice, stood at the head of the Toronaic Gulf, between the headlands of Sithonia and Pallene, about 60 stadia from Potidæa. The early part of its history is not marked by much prosperity. During the second Persian invasion of Greece, Artabazus, the general of Xerxes, captured the town, slaughtered its Bottiæan inhabitants, and gave it to the Chalcidians. It next came under the yoke of Athens; and not until the commencement of the Peloponnesian war, when the Spartan general Brasidas crushed the Athenian power in Chalcidice, did it assert its independence. At that time, however, the Olynthians began to play an important part in history. The maritime situation of their city, and its central position among the neighbouring independent towns, were the natural advantages with which they started. One of their first deeds was to exact from Amyntas, the embarrassed king of Macedonia, some additional territory. Then, on the broad principle of a common participation in all civil rights and privileges, they established a confederacy with the other Chalcidian and several of the Macedonian cities. In 383 B.C. their strength had become so formidable that they refused to restore the land previously conceded to them by the Macedonian monarch, and threatened to punish the towns of Acanthus and Apollonia for not joining the league. Yet it was the assumption of this bold attitude that led to the overthrow of Olynthus. The aid of Sparta was immediately solicited to punish the arrogant Olynthians, and after a stout resistance, they were forced to surrender to Polybiades in 379 B.C. Their federation was forthwith broken up; the seizure of Pydna, Methone, and Potidæa, not long afterwards, deprived them of all hope of ever reorganizing it; and they were left alone to cope with the rising destiny of Macedonia. They warded off their fate for some time by forming a league with Philip, the king of that country. At length their alliance with the Athenians, in 352 B.C., led to an open war with the Macedonian monarch in 350 B.C. All the eloquence of Demosthenes could not incite his countrymen to send adequate succour to their struggling allies: all the resistance of the besieged citizens themselves could not keep out the bribes of the intriguing Philip. In 347 B.C. Lasthenes and Eutychrates betrayed the city; all the inhabitants were sold for slaves; and every building was razed to the ground.

OMAGH, a market-town of Ireland, county of Tyrone, Ulster, on the left bank of the Strule, 27 miles S. of Londonderry. It is a neat, clean, and well-built town; the houses generally of stone, and the streets lighted with gas. Among the public buildings are the county court-house, an elegant building of Grecian architecture, the county jail, district lunatic asylum, infirmary, barracks, and union workhouse. The river is crossed by a handsome stone bridge. There are a parish church, a Roman Catholic chapel, and several dissenting places of worship. Omagh was burned by James II. in 1689, and again by accident in 1743. Market-day, Saturday. Pop. (1851) 3385.

OMAN. See ARABIA.

OMAR I., ABU HAFSSAH IBN-AL-KHATTAB, the second khalif of the Mussulmans, was the third cousin of Abdullah, the father of Mohammed. So inveterate an adversary was he at first to the new creed of Islam, that he set out one day to murder the prophet. Chancing, however, by the way to take up a copy of the Koran, and to read the 20th chapter, he was converted on the spot, and became from that hour the most zealous of the Moslems. His military talents and intrepid valour were forthwith devoted to the service of the founder of his religion. Among many other instances of fidelity that he gave was the promptness with which on one occasion he struck off the head of a plaintiff who had dared to question the justice of one of the prophet's judicial decisions. In fact, a spirit kindred to that which influenced his master seemed to influence him. "If God should wish," said Mohammed, "to send a second messenger to this world, his choice would undoubtedly fall on Omar." The self-sacrificing zeal of Omar came out into greater prominence at the death of the prophet in 632. When he saw the Mussulmans about to come to a schism touching the respective claims of himself and Abu Bekr to the caliphate, he put an end to the dangerous dispute by declaring for his rival. He then submissively undertook, and faithfully discharged, the duties of chamberlain to the khalif. Even when in the following year he was appointed successor to the khalifate by the death-stricken Abu Bekr, it was with reluctance that he accepted the appointment. "I have no occasion for the place," he said. "But the place has occasion for you," replied the dying khalif. In the position of "Emperor of the Faithful" the kingly spirit of Omar found its proper sphere. In no long time he communicated his prompt vigour and high-toned fanaticism to the whole military administration. Devoted lieutenants were placed in command of the several armies; the soldiers were disciplined by severe abstinence, and animated by hopes of a voluptuous paradise; and the Saracen conquests extended themselves with a rapidity greater even than in the days of the prophet himself. In 637 Saad Ibn Abi Wakkáss took Madáyin, the capital of Yezdejerd, King of Persia; in the following year Abu Obeydah Ibn Jerráh and Khâled Ibn Walíd completed the reduction of Syria; in 640 Amru Ibn-al-Ass had subjugated Egypt; and in 641 Mugheyrah subdued Armenia. A similar prosperity meanwhile pervaded the civil administration. The khalif was ruling in Medina with a wise and self-denying beneficence that rendered him in reality the father of his people. The poorest subjects ever found him an impartial judge between them and their high-born oppressors. It was his custom every Friday night to expend all the contents of the treasury upon public and charitable purposes. A part of the money was given as regular pay to the soldiers, another part constituted pensions for meritorious officers, and the rest was distributed among his dependants, according to their necessities. He reserved nothing to support his own state, but he lived in primitive simplicity on a small pittance which he earned by manufacturing leather belts. His food was barley bread, his drink water, and his garb an old gown torn in twelve places. Unarmed and unguarded, he mingled with his people, took his daily walks out into the country, and enjoyed his noontide repose under a wayside tree, or on the steps of the great mosque, among the beggars. At the same time, he was exhibiting in his life a model of Mohammedan piety. Much of his time was occupied in praying and preaching at the tomb of the prophet; occasional pilgrimages were made to Mecca; and the words of the Koran and the precepts of wisdom were ever upon his lips. Such a severely pure and sublimely simple morality could not fail to awaken in some minds an overpowering reverence and awe. Accordingly, it was said that the staff of Omar was more dreaded than the sword of his successors. In other minds it could not fail to excite hatred and revenge. Accordingly, an arrogant Persian slave, who had applied in vain to the khalif to be relieved of half the tribute paid to his master, swore to be avenged on the inexorable judge. Attacking him while saying the morning prayers in the mosque, he inflicted upon him three mortal wounds. After languishing for some days, Omar died in 643. It was in the reign of Omar that the famous Alexandrian library was burnt, and that several of the Mohammedan institutions began to be

Omar || Omen.

formed. (See Ockley's *Saracens;* Gibbon's *History;* Planck's *Dissertatio de Omaro Chalifa*, Lund. 1806; and Von Platen's *Geschichte der Tödtung des Chalifen Omar*, Berl. 1837.

OMAR II., the eighth khalif of the dynasty of the Ommiades, was the great grandson of Omar I., and succeeded Soliman in 717. In the midst of a luxurious and contentious people, he imitated the temperance and charity of his great ancestor. The chief purpose of his reign was to reconcile the followers of Omar and Ali, the two sects into which the Mussulmans were then divided, and to restore the latter to their property and privileges. Yet it was this generosity that led to his ruin. The Ommiades, dreading the fall of their faction, put him to death by poison in 720.

OMEN literally signifies a sign or indication of some future event, taken from the language of a person speaking without any intention to prophesy. This appears from the archaic form of the word, which was *osmen*. Varro says (*De Lingua Latina*, lib. v., c. 7, § 76) "*omen* quod ex ore primum elatum est, *osmen* dictum;" and Freund conjectures that this original form of the word may again be related to ὄσσα and ὄψ, which signified primarily a prophetic voice. Cicero remarks (*De Divinatione*, i. 45) that the Pythagoreans attended to the words not only of gods, but also of men, which they called *omens*. The term omen became subsequently applied to all signs, of whatever nature, from which men believed themselves capable of extracting any knowledge of future events. Omens are distinguished from all other modes of divination by their purely accidental character. To trace the history of this superstition, it would be necessary to begin almost with the origin of the race. There is perhaps no form of erroneous belief so common to all nations, and so similar in its special development, as that of omens. The causes of this uniformity are not far to seek. The desire, so peculiar to man, of drawing aside the curtain of mystery which hangs over his life, combined with the general sameness of human experience throughout the world, are sufficient to account for the striking coincidences often traceable between the ominous events of an eastern king and an ancient Roman, between an old Greek and an ignorant Englishman. Lightning, thunder, &c.; the motions and voices of animals, and particularly of birds; personal sensations of body and mind, &c., were regarded by the Greeks and Romans as peculiarly ominous. The Romans especially carried this superstition to an extravagant extent. (See AUGUR.) One curious variety in ancient divination is, that to a Greek the right hand denoted good luck, and the left the contrary; while the Roman exactly reversed this order.

The portentous or supernatural omens were either external or internal. Of the former kind were those showers of blood so frequently occurring in the Roman history, which were much of the same nature with the adventure of Æneas, which he calls *monstra deum*. Of the latter kind were those sudden consternations, which, seizing upon men without any visible cause, were imputed to the agency of the god Pan, and hence called *panic terrors*. But indeed there was hardly anything, however trivial, from which the ancients did not draw omens. That it should have been thought a direful omen when anything befell the temples, altars, or statues of the gods, need excite no wonder; but that the meeting of a eunuch, a negro, a bitch with whelps, or a snake lying on the road, should have been looked upon as portending bad fortune, seems absurd enough.

Of the countless occurrences still regarded by the ignorant and superstitious as of ominous import, the following may be cited as examples:—To break a looking-glass is extremely unlucky; for the party to whom it belongs will lose his best friend. If, going a journey on business, a sow cross the road, you will probably meet with a disappointment, if not a bodily accident, before you return home. To avert this you must endeavour to prevent her crossing you; and if that cannot be done, you must ride round on fresh ground. If the sow be attended with her litter of pigs, it is lucky, and denotes a successful journey. It is unlucky to see first one magpie, and then more; but to see two denotes marriage or merriment; three, a successful journey; four, an unexpected piece of good news; and five, that you will shortly be in a great company. To kill a magpie will certainly be punished with some terrible misfortune. If in a family the youngest daughter should be married before her elder sisters, they must all dance at her wedding without shoes. This will counteract their ill luck, and procure them husbands. If you meet or pass a funeral procession, always take off your hat. This keeps all the evil spirits attending the body in good humour. If, in eating, you miss your mouth, and the victuals fall, it is very unlucky, and denotes approaching sickness. It is lucky to put on a stocking the wrong side outwards; changing it alters the luck. When a person goes out to transact any important business, it is lucky to throw an old shoe after him. It is unlucky to present a knife, scissors, razor, or any sharp or cutting instrument, to one's mistress or friend, as they are apt to divide love and friendship. To avoid the evil effects of this, a pin, a farthing, or some trifling recompense, must be taken. To find a knife or razor denotes ill luck and disappointment to the party that finds it. (For much curious information on this subject, see Brand's *Popular Antiquities*, Bohn's edition, vol. iii., pp. 110–255.)

Omer, St || Ometepe.

OMER, ST, a strongly-fortified town of France, capital of an arrondissement of the same name in the department of Pas-de-Calais, stands on the River Aa, at the mouth of the Canal Neuffossé, 25 miles by railway S.E. of Calais. It is built partly on the declivity of a hill, and partly on low marshy land at its foot. It is surrounded by fortifications about 2½ miles in circumference, and is further defended by several strong and extensive outworks; but its chief strength consists in its being surrounded by marshes, and standing on the Aa, by means of which three-fourths of its circuit may be protected by water. The principal streets are broad and regular, and the town is generally well built; but the houses have a dull and gloomy appearance, being chiefly built of yellow or gray bricks. There are numerous public fountains and several fine promenades. The cathedral is a very fine building in the Gothic style, completed about the middle of the sixteenth century. The abbey church of St Bertin, at one time the finest Gothic edifice in French Flanders, is now in ruins from the effects of the revolution of 1830. The college, town-hall, arsenal, prison, and theatre, are the principal public buildings. There are several convents and hospitals, courts of justice and commerce, a public library of about 20,000 volumes, and an English college for the education of British Roman Catholics. Woollen cloth, paper, beer, brandy, and leather are among the principal manufactures; and an active trade is carried on in corn, wine, flax, wool, &c. Pop. (1856) 19,796.

OMERCOTE, a town of British India, in Scinde, stands in the Eastern Desert, 90 miles E. of Hyderabad, N. Lat. 25. 22., E. Long. 69. 47. Near the town is a fort 500 feet square, defended by mud walls and by numerous towers. Omercote was taken in 1813 by the ameers of Scinde from the Rajah of Joudpoor, and is the birth-place of the renowned Emperor Akbar.

OMETEPE, an island of Central America, near the western shore of the Lake of Nicaragua, in length about 20 miles, and in breadth 7 or 8. It is of volcanic origin, and contains two conical mountains of granite, thickly covered with forests, and of which one manifests occasionally signs of volcanic action. The other summit is the higher of the two, and its height has been estimated at 5252 feet above

the sea. The island contains two villages, Ometepe and Muvagalpa; and the entire population is about 1700.

OMNIUM is a term employed at the stock exchange to denote the aggregate value of the different stocks in which a loan is usually funded. (See M'Culloch's *Commercial Dictionary*.)

OMSK, a fortified town of Asiatic Russia, government of Tobolsk, stands on a barren sandy plain, at the confluence of the Om with the Irtish, 280 miles S.E. of Tobolsk; N. Lat. 54. 59., E. Long. 72. 54. It is well built, and contains, besides several churches, a governor's house, hospital, a military school, and a college for the education of interpreters for the army, in which the languages are taught. Manufactures of military clothing are carried on here; and here caravans start for Tashkend and Bokhara in Turkestan. The fortifications are modern, regularly constructed in the form of a polygon, and flanked by five bastions. Omsk was formerly the capital of a separate government, which has been divided between those of Tobolsk and Tomsk. Pop. 11,705.

OMUN, a town of Guinea, capital of a territory of the same name, stands on an island in the Old Calabar River; N. Lat. 6. 9., E. Long. 8. 15. Pop. estimated at 5000.

ON. See HELIOPOLIS.

ONATAS, an ancient Greek sculptor, was the son of Micon, and flourished at Ægina in the fifth century B.C. The ascertained facts of his life, as recorded by Pausanias, consist mainly of short notices of his principal works. At Pergamus there was an Apollo; in a sacred cave near Phigalia there was a black Ceres, with the horse's head; at Delphi there was a group of statues, the votive offering of the Tarentines; and at Olympia there were a Hercules, a Mercury, a bronze chariot, and a group representing the Grecian heroes drawing lots for the privilege of accepting the challenge of Hector. Onatas also practised painting. He was the assistant of Polygnotus in decorating the vestibule of the temple of Minerva Areia at Platæa, and in this capacity he painted a picture representing the expedition of the Argives against Thebes.

ONDA, a town of Spain, province of Castellon de la Plana, in a hilly country, 37 miles N. of Valencia. It has broad and generally well-paved streets, and several squares. Manufactures of earthenware, tiles, paper, &c., are carried on, and there are also numerous flour and oil mills. On a hill near the town stands a large and ancient fortress. Pop. 4517.

ONEGA, a lake of European Russia, in the government of Olonetz, lies to the N.E. of Lake Ladoga, next to which it is the largest lake in Europe. Its shape is irregular, its length from N.N.E. to S.S.W., being about 130 miles, and its greatest breadth about 50 miles; area estimated at 3400 square miles; its depth for the most part varies from 80 to 100 fathoms. Near the shores there are numerous small islands, but the centre is quite open. It is fed by the rivers Migra, Shuia, Vodla, and Vytegra; and discharges its waters by the Svir into Lake Ladoga. The shores are generally rocky, and the waters clear, abounding in fish.

ONEGA, *Gulf of*, the south-western arm of the White Sea, runs into the land in a S.E. direction, having a length of 75 miles, and a breadth at its mouth of 60 miles. It receives at its head the River Onega, which issues from Lake Latcha in Olonetz, flows N.E. to the confines of Archangel, and thence N.W. to the sea; total length, 270 miles. It is used for floating down timber, but is seldom navigated on account of the numerous falls and rapids.

ONEGLIA (Fr. *Oneille*), a seaport-town of the kingdom of Sardinia, capital of a province of the same name, in the division of Nice, at the mouth of the Impero, 55 miles S.W. of Genoa, and 41 E.N.E. of Nice. It is defended by fortifications, partly destroyed by the French in 1792; and contains a handsome church, court of justice, public offices, convents, grammar school, hospital, &c. Manufactures of soap, leather, &c., are carried on. The harbour is not good; but the situation is favourable for commerce. Pop. 5500. The province of Oneglia is mountainous in the N., and slopes gradually down to the sea. Its principal produce is olives. Pop. (1848) 60,072.

ONGOL, a town of British India, in the district of Nellore, presidency of Madras, 189 miles N. of Madras; N. Lat. 15. 30., E. Long. 80. 6. It is large, but consists for the most part of wretched mud hovels, covered with thatch; and has a ruinous fort. The scenery in the vicinity is picturesque; and the country, though not fertile, is rich in copper ore. Pop. of the town and district annexed to it, 31,666.

ONKELOS, the author of a celebrated Targum or Chaldee paraphrase of the Pentateuch, is supposed to have flourished during the first centuries of the Christian era, and most probably during the first. The notices of him are meagre and uncertain. He is mentioned four times in the Babylonian Talmud, but it is all but certain that he is there confounded more than once with the Greek paraphrast Aquila, who occasionally went by the same name. From the purity of his Chaldee, it has been inferred that he was a Babylonian; but as we do not possess any specimens of the Palestinian Chaldee of that time with which to compare his version, little weight can be attached to this conjecture. The knowledge of his paraphrase is supposed by Eichhorn and Bertholdt to have been confined to the Babylonian Jews only for a long time, as Origen and Jerome are silent regarding it. But it is to be remembered that these fathers had to do with *Greek* versions of the original text when they were occupied with biblical literature. Prideaux also concludes, from the excellency of his paraphrase, that he must have been a native Jew; and there can be no doubt that his knowledge of the Hebrew was worthy of all the praise bestowed on it by the Jews. In point of purity, the diction of his Targum approaches the style of Daniel and Ezra. His work is not properly a *paraphrase*, as he for the most part adheres with great literality to the original text, which renders his version useful alike for purposes of criticism and interpretation. The Targum of Onkelos was used by the Jews as a sort of dictionary of Hebrew words. The chief editions of it are those of Bologna, 1482 and 1490; Lisbon, 1491; Constantinople, 1505; Bomberg, in his rabbinical Bibles, 1518–1549; also in Buxtorf's rabbinical Bible, and in the Paris and London polyglotts. A Latin translation of it, with valuable notes, was published by Fagi at Strasburg in 1546; and an important work on the text of Onkelos appeared at Vienna in 1830, by S. D. Luzzato, under the title of *Philoxenus*. (See *De Onkelo Chaldaico, Pent. Paraph.*, Leipz. 1846; also Dr S. Davidson's *Biblical Criticism*, 1854.)

ONOMATOPŒIA (ὄνομα, *name*; ποιέω, *I make*), is the name applied to those words which are supposed to be formed from an imitation of natural sounds. Such words are occasionally to be found in all languages, but the Greek and German are particularly rich in them. (See *Dictionnaire raisonné des Onomatopées*, by Ch. Nodier, 8vo, Paris, 1808.)

ONOSANDER, the author of a famous work on military tactics, called Στρατηγικὸς Λόγος, is supposed to have lived about the middle of the first century after Christ, but nothing is known of his personal history. Subsequent Greek and Roman writers on military affairs made Onosander their text-book; and numerous generals, both in ancient and modern times, have expressed their obligations to him. His work was published first in Latin by Saguntinus, Rome, 1494; again in Latin by Camerarius in 1595; in French by Charrier, Paris, 1546; in Italian by Cotta, Venice, 1546; in English by Whytehorne, London, 1563; in Greek (for the first time) and Latin by Rigaltius, Paris, 1599. The best edition is that of Schwebel, Nurnberg, 1761, which

Ontario ‖ Oodeypoor.

contains the French version of Zur-Lauben, and notes from the MSS. of Jos. Scaliger and Is. Vossius. Onosander was a Platonist, and wrote a commentary on the *Republic* of his master, which is now lost.

ONTARIO, Lake. See Canada.

ONTENIENTE, a town of Spain, province of Valencia, on the right bank of the Clariano, 11 miles S.W. of San Felipe. It contains a ducal palace, town-hall, three churches, one of which has a lofty square tower, an hospital, and several schools. Cloth, linen, paper, brandy, and earthenware, are manufactured; but the industry of the town is in a declining state. Pop. 9508.

ONTOLOGY (*ὄν, being; λόγος, discourse*) is that branch of philosophy which investigates the nature and properties of *being*, or reality, as distinguished from *phenomenon*, or appearance. (See Metaphysics.)

ONYX. See Mineralogy.

OOCHEYRA, a native state of India, under the superintendence of the lieutenant-governor of the North-Western Provinces of Bengal. It lies between N. Lat. 24. 10. and 24. 36., E. Long. 80. 35. and 81. 4., and is bounded on the N.E. by the jaghire of Sohawul and by Rewah, E. by Rewah, S.E. by Myheer, and W. by Punnah; area, 436 square miles. The chieftain of this state having been convicted of the murder of his brother, was deposed and banished by the British government, who assumed the management of affairs during the minority of his son. He, however, when he assumed the power in 1838, found himself totally unable to conduct the government, and at his own request, the country was again put temporarily under British administration. The annual revenue is estimated at L.6632, and the population at 120,000.

OODEPOOR CHOTA, sometimes called *Mahur*, a district of British India, in the Rewa-Caunta, province of Guzerat, bounded N. by Deoghur-Barreea, E. by Allee-Mohun, S. by the districts of Akraunee and Mewassee, and W. by the territory of the Guicowar. It lies between N. Lat. 22. 2. and 22. 32., E. Long. 73. 47. and 74. 20.; and has an area of 1059 square miles. It is watered by the Orsung, an affluent of the Nerbudda. It was formerly an independent state under British protection; but in 1855, on the discovery of a systematic bribery of the natives attached to the political agent's office, the state was annexed to the British possessions. The capital is Oodepoor, a town on the Orsung, 105 miles S.E. of Ahmedabad, with a population of 6000.

OODEYPOOR, or Mewar, a Rajpoot state of India, bounded on the N. and W. by the British district of Ajmere and the native states of Godwar and Serohee, S. by the Myhee-Caunta, Dongurpore, and Banswara; and E. by Purtabghur, Tonk, Gwalior, and Boondee. It stretches from N. Lat. 23. 46. to 25. 56., and from E. Long. 72. 50. to 75. 38.; has a length of 150 miles, a breadth of 130, and an area of 11,614 square miles. The south-western part of this territory is occupied by the Aravulli Mountains, which extend thence along the frontiers of Oodeypoor northwards to Ajmere. To the north of Komulmair, this chain takes the name of Mhairwarra, and at this part it varies from 6 to 15 miles in breadth. The wild and deep glens of these mountains are occupied by Bheels, Minas, and Mairs; and the fastnesses of the southern part of the range have likewise given shelter to numerous native tribes, acknowledging no superior power, and paying no tribute. The geological formation of the mountains consists for the most part of granite, quartzite, and gneiss; and many valuable minerals are obtained here. Tin, silver, and copper are the principal metals that occur. The remainder of the country has an average elevation of 2000 feet above the level of the sea, and slopes gradually from S.W. to N.E. The principal rivers are the Banas and the Beris, flowing N.E. from the foot of the mountains. The rana or prince of Oodeypoor is regarded as the head of the Rajpoot States, although his supremacy is not acknowledged in any other respect; from which circumstance it has been inferred that these princes were formerly possessed of real power over the whole of Rajpootana. The state of Oodeypoor became tributary to the British government by the treaty of 1818; and the amount of tribute was originally fixed at L.22,400 per annum, but this was reduced in 1848 to L.20,000. A corps of Bheels was raised in 1841 at the joint expense of the British and Oodeypoor governments, in order to reduce to subjection the Bheel districts of the country; and this has been performed with complete success. Pop. estimated at 1,161,400.

Oodeypoor ‖ Oomrawuttee.

Oodeypoor, the capital of the above state, stands on a low ridge, in a valley surrounded by hills, 70 miles W. of Neemuch, 135 S.W. of Nusseerabad, and 395 N. of Bombay; N. Lat. 24. 37., E. Long. 73. 49. It presents a grand and beautiful appearance when seen from the east, but on a nearer approach is seen to be but ill built. The palace, a fine granite building 100 feet high, stands on a rock overlooking the city, and an artificial lake formed by the embankment of a stream. The town is said to have been founded and named after Oody Singh, Rana of Mewar, in 1568, and it was formerly very populous; but though in recent times the place has been recovering somewhat of its prosperity, it was estimated in 1818 to contain not more than 3000 houses.

OOJEIN, a city of India, in the territory of Gwalior, stands on the right bank of the Seepra, 152 miles S.W. of Goonah, 260 S.W. of Gwalior, and 598 W.S.W. of Allahabad; N. Lat. 23. 10., E. Long. 75. 47. It is of an oblong form, 6 miles in circumference, and is surrounded by a wall of stone, with round towers. The houses are very much crowded together, and are for the most part built either entirely of wood, or of a wooden framework filled up with brick, with roofs in some cases sloping and tiled, and in others consisting of terraces, after the eastern fashion. The principal bazaar consists of a broad and well-paved street, lined with houses of two stories in height, the lower of which, of stone, contain the shops, and the upper, of brick, form the dwellings. There are in the city four mosques and many Hindu temples; a large and convenient, though not very handsome palace belonging to the Scindia family; and an observatory, built by Jai Singh, Rajah of Jeypoor, and minister of Mahomed Schah, Emperor of Delhi (1719–1748). Oojein is one of the seven sacred cities of the Hindus; and from it the degrees of longitude are calculated by the Hindu geographers. It is of great antiquity; being believed to be the place mentioned by Ptolemy under the name of *Ozoana*. Vikramajit, King of Oojein, who ascended the throne in 57 B.C., was so celebrated in India that the Samvat era, which dates from the beginning of his reign, is still universally used throughout Hindustan; and his son Chandrasen is said to have ruled over the whole of India. Oojein fell into the power of the Mohammedans in 1310. At this time it was the capital of Malwa; and along with this country it afterwards came under the power of the Patans, but was recovered by Akbar in 1561. In the middle of the eighteenth century it was conquered by the Mahrattas, and was regarded as the capital of Scindia's dominions till 1810, when the seat of government was transferred to Gwalior.

OOMRAWUTTEE, a town of British India, in one of the districts of Hyderabad, ceded by the Nizam to the British government, 245 miles N. of Hyderabad, and 350 N.E. of Bombay. It is of great commercial importance on account of the cotton grown in the surrounding districts, which is conveyed to the town, there cleaned, and sent for exportation to Bombay and Calcutta. Many mercantile firms are established here; and most of the great houses in Upper India have either branches or correspondents at

Oorcha || Opera.

Oomrawuttee. This place enjoys great advantages on account of its freedom from transit duties; and will, before long, be connected with Bombay by a line of railway.

OORCHA, a town of India, capital of a raj or principality of the same name in Bundelcund, 131 miles N. of Saugor, 142 S.E. of Agra, and 743 N.W. of Calcutta; N. Lat. 25. 21., E. Long. 78. 42. It is built on a rocky hill, is about 3 miles in circuit, and is surrounded by an uncemented wall of unhewn stones, which has three lofty gateways. In the town is a fortress, separated from the rest of the buildings by a branch of the Betwa, which is filled with water during the time of the inundations, and crossed by a wooden bridge. In the fortress stands the residence of the rajah, and a handsome palace; while in the town there is a temple adorned with lofty spires. The raj of Oorcha, which is also frequently called Tehree, from a town of that name, where the rajah generally resides, has an area of 2160 square miles, yields a revenue of L.60,000 per annum, and maintains a force of 7000 or 8000 men. Pop. of the raj, 192,000.

OORT, ADAM VAN, the teacher of Rubens, was born at Antwerp in 1557. His early style, acquired under the tuition of his father, was marked by careful and correct drawing, and raised him to a high place in his profession. He was employed to decorate many of the churches and public edifices in Flanders; he received into his school of painting such promising pupils as Rubens, Jordaens, Franck, and Van Balen; and so excellent did his artistic skill become, that, according to the greatest of his scholars, a course of study at Rome was the only training requisite to render him the first historical painter of his day. But the loose moral character of Oort prevented his further success. His cruel outbursts of passion drove away all his pupils except his future son-in-law Jordaens; his intemperance palsied his hand and broke up his studious habits; and the pictures he executed before his death, in 1641, were full of negligence and mannerism.

OOSTERHOUT, a town of Holland, in the province of North Brabant, 5 miles N.E. of Breda. It has a town-house, churches, and schools. There are here potteries, producing a kind of earthenware which is highly prized; besides breweries, tanneries, corn-mills, &c. Some trade is carried on in corn, timber, and cloth. Pop. 7500.

OOTAKAMUND, a town of British India, presidency of Madras, district of Coimbatoor, stands on the Neilgherry Hills, at an elevation of 7300 feet above the sea, 32 miles N.W. by N. of Coimbatoor. It is partly occupied by natives, and partly by Europeans; the houses of the latter being scattered along the slopes of the valley in which it stands, while those of the natives are more closely collected together. There is an elegant church, and public gardens. Ootakamund is the principal as well as the most elevated sanatory station on the Neilgherry Hills. It was founded in 1822.

OPERA, a lyrical drama set to music in recitations, airs, duetts, trios, quartetts, choruses, and *finales;* preceded by an instrumental overture, and accompanied by an orchestra; and, when performed, enforced and embellished by action and declamation, and appropriate costumes and scenery. The opera appears to have originated at Florence about the end of the sixteenth century. (See Doni's Works, *passim.*) The Italians divide their operas into four kinds; the *sacred opera*, the *serious opera*, the *semi-serious opera*, and the *opera buffa*, or *comic opera*. The French have their *grand'opera*, in which the whole lyrical drama is sung; and the *opera comique*, in which the singing is intermingled with spoken dialogue. The Germans have a greater variety of such distinctions of operas; as the *grand opera*, the *serious opera*, the *tragic opera*, the *heroic opera*, the *romantic opera*, the *allegorical opera*, the *military melodrama*, the *comic opera*, and some others.

(Much amusing and interesting matter relative to the rise and progress of the opera may be found in Dr Burney's *Tours* and *History*, in the Baron de Grimm's *Correspondence*, and in various German periodicals conducted by musicians. See also Arteaga, Manfredini, Signorelli, &c. For some technicalities relative to operatic music, see the article MUSIC.) (G. F. G.)

Ophicleide || Ophir.

OPHICLEIDE. See MUSIC.

OPHIOLOGY (*ὀφις, a serpent, λογος, a discourse*) is that branch of zoology which treats of serpents. (See REPTILIA.)

OPHIR, אוֹפִיר, the name of a place, country, or region famous for its gold, which Solomon's ships visited in company with the Phœnician. Regarding its locality there are several interminable controversies. We shall lay before the reader the exact amount of our information respecting the subject, and show how far it applies to what appears to be the three most probable localities,—namely, Arabia, Africa, and India. Our information amounts to this, that King Solomon made a navy of ships in Ezion-geber, which is beside Eloth, on the shore of the Red Sea, in the land of Edom; that his Phœnician neighbour and ally, Hiram, King of Tyre, sent in this navy his servants along with the servants of Solomon; that they came to Ophir, and fetched from thence gold, and brought it to Solomon; and that they brought in the same voyage algum or almug trees and precious stones (1 Kings x. 11), silver, ivory, apes (or rather monkeys), and peacocks (according to some, pheasants, and to others, parrots). The first theory which appears to be attended with some degree of evidence not purely fanciful is, that Ophir was situated in Arabia. In Gen. x. 29, Ophir stands in the midst of other Arabian countries. Though gold is not now found in Arabia, yet the ancient writers, both sacred and profane, ascribe it to the inhabitants in great plenty. We may also suppose, along with some authors, that Ophir, situated somewhere on the coast of Arabia, was an emporium at which the Hebrews and Tyrians obtained gold, silver, ivory, apes, almug trees, &c., brought thither from India and Africa by the Arabian merchants, and even from Ethiopia. In favour of the theory which places Ophir in Africa, it has been suggested that we have the very name in אופיר, *afir*, and that the Chald. Targumist on 1 Kings xxii. 48 so understood it, where he renders תרשיש by אפריקה; probably inferring from 2 Chron. xx. 36, that to go to Ophir and to Tarshish was one and the same thing. Origen also says, on Job xxii. 24, that some of the interpreters understood Ophir to be Africa. Michaëlis supposes that Solomon's fleet, coming down the Red Sea from Ezion-geber, coasted along the shore of Africa, doubling the Cape of Good Hope, and came to Tarshish, which he, with many others, supposes to have been Tartessus in Spain, and thence back again the same way; that this conjecture accounts for their three years' voyage out and home; and that Spain and the coasts of Africa furnished all the commodities which they brought back. Others have conjectured that Solomon's fleet, after reaching Spain by that course, came home by the Mediterranean; thus completing a circuit which Herodotus relates to have been completed by the mariners of Necho, King of Egypt. In behalf of the conjecture that Ophir was in India, the following arguments are alleged,—that it is most natural to understand from the narrative that all the productions said to have been brought from Ophir came from one and the same country, and that they were all procurable only from India. The Sept. translators appear to have held this opinion, from rendering the word Σωφίρ, Σουφίρ, Σωφιρά, which is the Egyptian name for that country. Josephus also expressly and unhesitatingly affirms that the land to which Solomon sent for gold was "anciently called Ophir, but now the Aurea Chersonesus, which belongs to India;" and the Vulgate renders the

Opie. words "the gold of Ophir" (Job xxviii. 16) by "tinctis Indiæ coloribus." There are several places, such as Malacca, comprised in that region which was actually known as India to the ancients, any of which would have supplied the cargo of Solomon's fleet. (Among other works on this controversy not before referred to, see Wahner, *De Regione Ophir;* Tychsen, "De Commerc. Hebr." in *Commentt. Gott.* xvi. 164, &c.; Huetii *Commentatio de Navigatione Salomonis;* Reland, *Dissertt. Miscell.* i. 172; or in Ugolini *Thesaurus*, vii.)

OPIE, JOHN, an eminent painter, was born in the parish of St Agnes, near Truro in Cornwall, in 1761. Although he was the son of a poor carpenter, and was placed at a very early age in his father's shop, his artistic genius could not be suppressed. He decorated the walls of his paternal cottage with likenesses of his friends, and covered the deals which he planed with comic drawings in red chalk. But it was Dr Wolcott, better known as "Peter Pindar," who was the chief instrument in fostering his talents. That eccentric satirist, who was then a physician at Truro, hired him as a menial, encouraged his aspirations, and took the charge of his fortunes. After allowing him to gain facility of hand by practising as an itinerant portrait-painter, he brought him to London in 1781, and with both prose and verse introduced him to the world as "The Cornish Wonder." The public, who are always glad of anything to stare and gape at, were roused. The peasant artist soon found himself the gazing-stock of all the minions of fashion; it became no uncommon circumstance for the street in front of his house to be blocked up with carriages; and before a year had passed, he had painted the principal nobility, and had realized a handsome sum of money. But the tide of success which had risen so suddenly as suddenly ebbed. The fashionable world began to perceive that the manners of the rustic painter were too homely to be tolerated in their refined presence, and that his style of portraiture was too vigorous and natural to do justice to their aristocratic features. Accordingly they deserted him for some other novelty; the rest of the public followed their example; and even Peter Pindar, offended at some neglect, either real or imaginary, began to cast gibes at the man he had formerly eulogized. It was under these unexpected disappointments that the full strength of Opie's character began to appear. He set himself to remedy his defective education by studying the English classics, and by mingling in literary society. At the same time, his devotion to his art continued unabated; and though dexterous in executing a picture, he became careful in conceiving it, and fastidious in correcting it. The results of such unwearied industry were great and palpable. It is true that he never attained to refinement in his portraits, or to poetry in his historical pieces; but both in his portraits and historical pieces there was latterly a power of imitating the colouring of nature which, according to West, no artist had ever rivalled. Some of his historical pieces came into favour with the public; and his portrait of Fox was for a while the talk of the town. Soon after 1801 more commissions began to flow in upon him than he could execute. In 1807 the height of his ambition was attained, when he was raised to the professorship of painting in the Royal Academy. But he did not long enjoy his elevation. After delivering four lectures on Design, Invention, Chiaroscuro, and Colouring, he died on the 9th April 1807, and was buried near Sir Joshua Reynolds. His widow, the well-known writer, published his *Lectures on Painting*, with a Memoir, in 1809.

Some of the most popular pictures of Opie are, "The Murder of James I. of Scotland," "The Death of Rizzio," "Arthur taken Prisoner," "Hubert and Arthur," "Belisarius," and "Juliet in the Garden." (Cunningham's *Lives of Painters*, &c.)

OPIE, *Amelia*, the wife of the preceding, was the daughter of Dr Alderson, a physician in Norwich, and was born there in 1769. The circumstances of her early life gave the bent to her after-career. In her girlhood she beguiled the solitude of her father's summer-house by composing songs and tragedies; on her visits to London, the superior society into which the accomplishments of her mind and the graces of her person introduced her, served to stimulate her aspirations; and after her marriage in 1798, she was encouraged by her husband to become a candidate for literary fame. Accordingly, in 1801, she published a novel entitled *Father and Daughter*. Although this tale showed no artistic ability in dealing either with incidents or with characters, yet it was the work of a lively fancy and a feeling heart, and speedily brought its author into notice. She was encouraged to publish a volume of sweet and graceful poems in 1802, and to persist in the kind of novel-writing which she had so successfully commenced. *Adeline Mowbray* followed in 1804, and *Simple Tales* in 1806. The death of her husband in 1807, and her return to Norwich, did not slacken her industry. She published *Temper* in 1812, *Tales of Real Life* in 1813, *Valentine's Eve* in 1816, *Tales of the Heart* in 1818, and *Madeline* in 1822. At length, in 1825, her assumption of the tenets and garb of the Quakers checked her literary ardour, and changed her mode of life. Besides a volume entitled *Detraction Displayed*, and several contributions in prose and verse to various periodicals, nothing afterwards proceeded from her pen. The rest of her life was spent in travelling and in the exercise of Christian benevolence. She died at Norwich in 1853. A Life of Mrs Opie, by Miss C. L. Brightwell, was published in 1854.

Opie ‖ Opium.

OPITZ, MARTIN, *Von Boberfeld*, the father of modern German poetry, was born at Bunzlau in Silesia in 1597. At the universities of Frankfort and Heidelberg he studied his native literature, in addition to the regular branches of education. During the migratory life which he then began to lead his favourite study was not forgotten. While occupying the chair of philosophy and humanities at Weissenburg, in 1622, he published his first poem, *Zlatna oder von der Ruhe des Gemüths*. At Vienna, in 1624, the death of the Archduke Charles afforded him a subject for an elegy, a production which was rewarded by Ferdinand II. with a laurel crown and a patent of nobility. During his residence at Dantzic, where he held the office of secretary and historiographer to the Polish king, he published several poems and translations, among which were versions of the *Antigone* of Sophocles, and of the *Psalms*. It was in this city that he was cut off by the plague in 1639. Opitz is now remembered less on account of his poetical excellence than for the correctness and purity of style which he introduced into German poetry. He was also the author of several prose works, of which his treatise on German Poetry is most esteemed. (See in particular *Umstandliche Nachricht von des weltberühmten Schlesiers M. Opitzen von Boberfeld's Leben, Tode und Schriften*, von C. G. Lindner, 2 vols., 1740–41.)

OPIUM, the concrete juice of the white poppy (*Papaver somniferum*,) a plant of the natural order *Papaveraceæ*. It is obtained by incisions made in the green capsule of the plant when nearly at maturity, from which it exudes as a milky juice that concretes in a brownish mass, which is scraped off the capsule, and collected into lumps such as are found in the market. It is termed by Dioscorides μηκωνος ὀπος, *sap* or *juice of the poppy*. It was anciently prepared in nearly the manner above described, and seems to have obtained its name from the Greek word ὀπος. It was used as a hypnotic by the ancients; and was long employed in modern times ere it was analysed. About 1812 it was found by Serturner to be a compound substance; and the subsequent researches of Pelletier, Robi-

Opium. quet, Mülder, Anderson, and others, have detected in it no less than sixteen ingredients, besides saline matters,—

1. Morphine	9. Papaverine.
2. Narcotine.	10. Brown extract.
3. Thebaine.	11. Caoutchouc.
4 Codeine.	12. Resin.
5. Narceine.	13. Concrete oil.
6. Porphyroxine.	14. Gum.
7. Meconine.	15. Bassorine.
8. Meconic acid.	16. Lignine.

The first nine are crystallizable, the rest amorphous.

The therapeutic or medicinal properties of the drug are due to the morphine alone; and it was a vast improvement in pharmacy to separate it from the other ingredients, which impair its power, or produce disagreeable effects in certain individuals. Thus, some persons suffer from headache, nausea, or intense itching of the skin, from crude opium, who do not experience these effects from morphia, which, on account of its insolubility in water, is generally administered as a muriate or an acetate. The quantity of morphine differs somewhat in different kinds of opium. The best Turkey opium produces usually from 6·25 to 7·80 per cent. of pure muriate of morphia, containing 12 per cent. of the acid; but it is stated that an opium obtained from the purple variety of the *P. somniferum* in Germany contains a much larger quantity of this valuable principle. The only other principle in opium of importance is the meconic acid, which affords to the toxicologist his best means of detecting the administration of opium or laudanum with a criminal intent.

Formerly all our opium came from Asia Minor, and the opium of Turkey is still considered the best; but a few years ago the poppy began to be extensively cultivated in India, especially in Bengal and Malwah, the greatest part of which is sent to China, to the extent, in 1856, of 4,735,500 lb. From Turkey, in the same year, we imported 74,914 lb.; from Egypt, 2958 lb.; from the Black Sea and other places, 2652 lb.; or in all, 81,524 lb. Of this quantity, 42,329 lb. were entered for home consumption, but principally employed in the manufacture of the salts of morphia, which are largely exported to various parts of the world. Good opium is also produced in England, in France, and Germany; but the principal European supplies come from Asia, though it has been successfully cultivated in this quarter of the globe.

A good description of the preparation of opium in India is given by Dr Joseph Hooker, who studied the process at Patna, one of the principal opium districts. The capsules are incised by a rude sort of knife with three or more blades, called *nustur*, which is drawn along the capsules during the hottest time of the day: the white juice exudes and concretes into opium, which is scraped off in the morning. If the night dews are heavy, or if rain falls in the interval, the quality of the drug is much impaired. By 10 A.M. the process of collecting is finished; and an expert operator will thus produce in twenty-four hours about half a pound of opium. Dr Hooker considers the Indian opium inferior to the Turkish; and it certainly yields less morphia. The opium when collected is put into jars, called *godowns*, for transportation to Patna, where it undergoes the following process to prepare it for the market, according to Hooker:—

"At the end of March the opium jars arrive at the godowns by water and by land, and continue accumulating for some weeks. Every jar is labelled and stowed in a proper place, separately tested with extreme accuracy, and valued. The contents of all are thrown into capacious vats, occupying a very large building, from whence the mass is distributed to be made into balls for the markets. This operation is conducted in a long paved room, up and down which the workers sit; every man is ticketed, and many overseers are stationed to see the work properly conducted. Each workman sits on a stool, with a double stage before him, and a tray. On the top stage is a tin basin containing opium sufficient for three balls; in the lower, another basin containing water. In the tray stands a brass hemispherical cup, in which the ball is worked. To the man's right hand is another tray with two compartments—one containing thin pancakes of poppy petals, the other a cupful of sticky opium-water, made from refined opium. The man takes the brass cup and places a pancake at the bottom, smears it with opium-water, and with many plies of the pancake, makes a coat for the opium. Of this he guesses at one-third of the mass before him, puts it inside the petals, and agglutinates many other coats over it. The balls are again weighed, and reduced or increased to a certain weight, if unequally made up. At the day's end, each man takes his work to a rack with numbered compartments, and deposits in it that which answers to his own number. From thence the balls are carried by boys to the drying-room, each being put in a clay cup, and exposed in tiers in the enormous building called the drying-room, where they are constantly examined and turned, to prevent their being attacked by weavils, which are very prevalent during north-east winds—little boys creeping along the racks all day long for this purpose. When dry, the balls are packed in two layers of six each, in chests, with the stalks, dried leaves, and capsules of the poppy plant, and sent down to Calcutta for the opium market, whither every ball is exported. A little opium is prepared, of very fine quality, for the Medical Board, and some for general sale in India; but the proportion is trifling, and such is made up into square cakes. A good workman will prepare from 30 to 50 balls a day—the total produce being 1000 to 1200 a day. During the working season 1,353,000 balls are manufactured for the China market alone."

The principal use which the Chinese make of opium is to smoke it with tobacco, when it produces a languor so pleasing and seductive that those who indulge in it are as little able to resist the temptation to repetition as the drunkard to relinquish his strong potations. The effects of this vice are even more debasing than that of habitual intoxication by alcoholic liquors,—enfeebling rapidly both the mental and bodily powers. The Chinese have long been the principal consumers of opium; and notwithstanding the drug has latterly been cultivated to a considerable extent in China, the imports into that empire have been largely and rapidly increased. So much is this the case, that while the imports in 1827–30 did not exceed 16,000 chests, they now (1856-57) amount to from 65,000 to 70,000 chests—that is, to from 10,000,000 lb. to 10,800,000 lb.[1] This opium is entirely supplied by India; and being subjected to a high duty, partly levied on its production and partly on its exportation, it produces to the Indian treasury a net return of nearly four millions sterling a year (in 1855-56, L.3,714,353); every shilling of which is, of course, derived from the foreign consumers of opium, or Chinese. This system has been much objected to, but without any good reason. The high price charged for the drug must, of course, lessen its consumption, and consequently, also, the injurious effects which it is said to occasion; so that, while the system we adopt yields a large revenue, it obstructs what is said to be the demoralization of the Chinese. The increasing use of opiates among our operative classes has been strongly condemned by many writers, though we would fain hope that the prevalence of the practice has been somewhat exaggerated; and the inferences on this head, from the quantity of opium imported, do not take into account the large exportation of salts of morphia from Britain, which in 1856 amounted to no less than 112 lb.—equivalent to two-thirds of the opium entered for home consumption.

(See *Annalen der Pharmakie*, tom. iv.; *Journal de Pharmacie*, tom. viii.; *Parliamentary Reports*, "Poisons;" Christison's *Toxicology*, and *Dispensatory*; *Pharmaceutical Journal*, vol. xi.; Dr J. Hooker's *Botanical Journal*, vol. i.)

Oporto. OPORTO (*o Porto*, "The Port"), the second city of the kingdom of Portugal, province of Entre Douro e Minho, the

[1] 40,000 to 50,000 chests of Bengal opium, at 160 lb. a chest, and from 20,000 to 25,000 Malwa opium, at 140 lb. per chest.

Oporto. best cultivated and the most fruitful province in the kingdom, stands on the northern bank of the Douro, about a league from its mouth, in Lat. 41. 11. 15. N., Long. 8. 8. 22. W. Passengers by steamers and the larger vessels usually land at the town of São João de Foz, built on low land at the mouth of the river, where there are a castle and lighthouse. The dangerous bar of the Douro, upon which many vessels have been wrecked, is near Foz. To add to the difficulties of the passage, the bar is continually altering its position. The river itself is liable to sudden risings after heavy falls of rain on the mountains.

It appears from the *Itinerary* of the Emperor Antoninus, that in the year A.D. 160 there was a town on the river over against the present city which bore the name of Cago or Gaia. At a subsequent period the Alani entered Lusitania, and founded a city on the site of the present Oporto, which they called *Castrum Novum*, in distinction to the *Castrum Antiquum* of the opposite bank. About the year 540 this portion of Lusitania was taken possession of by the Arian Goths under Leovogildo, who caused all persons refusing to adopt his opinions to be put to the sword, even, it is said, his own sons. In 716 the Goths gave way to the Moors under Abdul Hassan, who conquered Galicia, and seized the whole country as far as the River Douro. The place afterwards fell into the hands of the Christians, and they were attacked by the Moors under Abderrahman in 820. A battle was fought at Campanha, in which Alfonso I. commanded the Christians. The Moors were defeated, and a part of the city whence the Christians issued to the contest received the name *Batalha*, which it still retains. However, such was the fluctuating fortune of the contending races, that the place afterwards fell under the power of the Moors, by whom it was retained until 1092, when certain knights of Gascony, commanded by Don Alfonso Fredrico, subdued the city, and it was ever afterwards retained by the Christians. In later times Oporto has been notorious for popular outbursts. In 1756 there was an insurrection on account of the creation of the wine monopoly, and twenty-six persons suffered death. On the 11th May 1809 the Duke of Wellington passed the Douro here, and surprised Soult, who fled. The latest event of importance was its siege in 1832 and 1833 by Dom Miguel, and its successful defence by Don Pedro with 7500 men. In this siege the city suffered severely, and more than 16,000 of the inhabitants were killed.

Oporto extends for about 3 miles along the river. The streets, though irregular, are tolerably well paved, kept pretty clean, and some of them are spacious. The principal buildings are,—the cathedral, originally of pointed Gothic, but barbarously mangled in later times; the bishop's palace, perched on a high rock, and containing a noble staircase; the Torre dos Clerigos, a tower 210 feet high, built of granite in 1779, commanding an extensive view, and visible from vessels 30 miles away; the English factory-house, a building 70 feet by 90, erected in 1790, and containing a ball-room, library, refreshment-room, &c.; the building, formerly a Capuchin monastery, in which the museum, and public library containing 70,000 vols., are deposited; barracks capable of housing 3000 men; the Royal Hospital, commenced, like many of the edifices in Portugal, on an extravagant scale of vastness, and therefore incomplete; the foundling hospital, which annually receives from 1000 to 2000 infants; and a large Italian opera-house. Amongst the numerous churches, that of S. Francisco is large and somewhat imposing; and the Cedo-feita church, very curious. The church of our Lady of Lapa is a handsome Corinthian edifice, forming a well-known landmark. The chapels are very numerous; the monasteries, which formerly existed here to the number of twelve, and the five convents, have been suppressed. The English have a chapel and cemetery, and maintain a chaplain here. Oporto is lighted with gas, manufactured by a company, of which the chief proprietors are British residents. Electro-telegraphic wire connect Oporto with the government offices at Lisbon. Oporto.

The manufactures of Oporto are on a small scale, and the produce is of a very poor quality. There are iron-foundries, cooperages, sugar-refineries, and roperies; boats and small ships are built here. Oranges are grown in the neighbourhood, and camellias flourish remarkably well. The olive tree receives less attention here than in other parts of Portugal. Oporto has a botanical garden. Small quantities of tin and quicksilver are extracted in the neighbourhood. The chief exports, besides wine, are oil, oranges, and other fruits, cream of tartar, shumach, and cork. The principal imported articles are,—corn, rice, coffee, sugar, manufactured goods, hardware, and timber. Oporto has a bank which enjoys good credit, and is of great use in commercial operations; four insurance companies, a government industrial school, a lyceum, an *academia polytechnica* with ten chairs, a medico-chirurgical school with nine chairs, an academy of fine arts with four chairs, and a public library belonging to the municipality. Nine daily newspapers are published here. The receipts at the custom-house in 1853 amounted to upwards of L.33,200, and the receipts from the duties levied on articles of consumption entering the city amounted to L.22,250 in the same year. Portuguese steamers connect Oporto with other parts of the kingdom, and British steamers establish a communication with England. The wine known in this kingdom as *port*, and which has hitherto found its largest market here, is produced in a mountainous district called the Alto-Douro, which is distant from Oporto about 15 leagues. The dimensions of the district are about 8 leagues by 4, and the rocks upon which the soil rests are of igneous origin. The surface is extremely irregular, and the roads very bad. The climate is an extreme one, being cold in winter and hot in summer. Until the vine disease entered the district it produced about 105,000 pipes of wine annually, the average produce being rather more than one pipe per acre. The expense of a pipe of wine varies from 15s. to 60s., according to the nature of the ground. The vines are cultivated in terraces, and not suffered to grow higher than 3½ feet, the effect being by no means pleasing to the eye. In the course of a year the soil is turned over three times: firstly, in autumn, when the earth is hollowed round the roots of the plants with the view of catching the rain; secondly, in April, when the earth is replaced round the roots with the view of defending them from the sun's power; thirdly, when the fruit begins to ripen. The chief part of the work of cultivation is done by men from Galicia, about 8000 of whom are thus employed in the district. The pay of the men is from sixpence to eightpence a day, with food. The vintage commences in the latter part of September, and continues nearly a month. Women and children pick the grapes, which are removed in baskets by Gallegos (the inhabitants of Galicia), who carry them to the wine-press, where the juice is extracted by the pressure of men's feet. The must is placed in casks to ferment; and after this process has been gone through, the wine is transferred to large vats, where a second fermentation ensues. Great Britain is the great market for port wine, but a very small part of that which reaches the island is the pure produce of the grape. Certain regulations of the Portuguese government hamper the importer—no wine being permitted to leave the country without the sanction of a committee of persons, who only allow a strong, black, sweet wine to be exported. It is said to follow, that the best wines of the country are either kept back, or must be treated with brandy, elder-berries, &c., before they can obtain the necessary license. None of the beautiful white wines of the district reach this country; and wines which would rival the claret, Burgundy, &c., of other places, we never hear of. Of late years a disease has ravaged the

Oppeln ‖ Oppian.

grapes of Portugal, and the produce of wine has been greatly reduced. Previously the average annual produce of the Alto-Douro district amounted to between 80,000 and 90,000 pipes, of which about 28,000 pipes were exported. In 1854 Great Britain imported 22,800 pipes of port wine, that being about the average amount for the preceding ten years.

The length of Oporto along the river is nearly 3 miles, and its inhabitants amount to about 90,000. Many British merchants, chiefly connected with the wine trade, reside here; and there is a British consul, as well as an English chaplain and English medical men. The public conveyances consist of hackney coaches, bullock carriages, and a few omnibuses, connecting some of the neighbouring towns with Oporto. A railway is in contemplation between this place and Lisbon, but many years must elapse before such an expensive work can be completed. One of the chief wants of the kingdom is good internal communication by means of roads, but the impoverished state of the country is too great to allow of these being soon made.

OPPELN, a government of Prussia, occupying the greater part of Upper Silesia, is bounded on the N. by the government of Posen, N.W. and W. by that of Breslau, S. by Austrian Silesia, and E. by Poland. It has an area of 5148 square miles, the greater part of which is covered with mountains and hills. The Oder traverses it from S. to N.; and the only other large river is the Vistula, which forms the boundary of the government to the S.E. There are, however, numerous small lakes and ponds which give rise to streams; and the country is also watered by the Neisse, an affluent of the Oder from the E. The mineral riches of the district are considerable, consisting of coal, iron, zinc, tin, argentiferous lead, &c. The climate is cold and moist, and the ground is covered with snow for a great part of the winter. A considerable part of the surface is occupied with forests; and though the soil is not so fertile as that of Lower Silesia, some of the valleys are very productive; but the quantity of corn grown is not sufficient for the consumption. Cattle and sheep are kept in large numbers. Manufactures are not carried on to any great extent, except those of hardware, steam-engines, leather, and woollen stuffs. Weaving is also carried on in the mountainous districts. Some trade is carried on in timber. Pop. 1,014,383.

OPPELN, a town of Prussia, capital of the above government, on the left bank of the Oder, 51 miles S.E. of Breslau. It is surrounded by walls, and entered by four gates. There are here several churches, a synagogue, schools, a town-hall, arsenal, hospitals, &c. Manufactures of linen, leather, earthenware, and other articles are extensively carried on; and there is a considerable trade in timber, lead, zinc, wines, &c. Pop. 8439.

OPPIAN, a Greek poet, was born at Corycus, or Anazarba, in Cilicia, towards the close of the reign of Marcus Aurelius, in the second century after Christ. His father, Agesilaus, was equally distinguished for rank and learning, and he caused young Oppian to be instructed in music, geometry, and the belles-lettres. Septimius Severus having seized upon the throne, arrived at Anazarba, and immediately the senate of the place threw themselves at the feet of the conqueror. Agesilaus stood aloof upon this occasion, being too much engrossed with his philosophical inquiries,—a circumstance which so irritated Severus that he deprived the philosopher of all his property, and banished him to the island of Melita in the Adriatic. Thither Oppian followed his father, and it was in this compulsory retreat that he conceived and executed his two poems on *Fishing* (Ἁλιευτικά), and on *Hunting* (Κυνηγετικά), written in Greek hexameters. When they were finished he went to Rome, and presented them to the son of Severus, Antoninus Caracalla, who esteemed them so highly that he permitted the author to demand of him whatever recompense he pleased. Oppian asked only for the release of his father, with permission to the latter to return to his own country. The emperor not only granted the favour, but added the gift of a piece of gold (about 15s. 6d. of our money) for each of the verses which he had just heard recited. If, as Suidas affirms, these verses amounted to 20,000, never did poet receive so splendid a recompense. But Oppian did not long enjoy his good fortune. Scarcely had he returned to his own country, when he sunk into the grave, at the early age of thirty, having fallen a victim to the plague, which then desolated the city of Anazarba. His fellow-citizens erected to his memory a magnificent tomb, whereon was engraved an inscription in Greek verse, which still remains. This is all that we learn of Oppian from the anonymous Greek historian of his life, whom all the succeeding biographers have faithfully copied. We must, however, except Schneider, the learned editor of his works, who, being struck with the disparity of style and poetic embellishment which he remarked in the poems on the *Chase* and on *Fishing*, conceived that two works which were so different in merit could not possibly have been the productions of the same author. Besides, the author of the *Cynegetica* states in two different passages that his native place was a city on the Orontes in Syria. The critic accordingly supposed that there were two Oppians, the first of whom, a native of Cilicia and author of the *Halieutica*, preceded the second by several years. In the opinion of Schneider, it is to the latter that we are indebted for the *Cynegetica*, in which the author has, according to him, attempted to reproduce, but with great inferiority of talent, the manner and some of the imagery of the first Oppian. Belin de Ballu, however, attempted to refute this hypothesis in the preface to his Greek edition of the *Cynegetica*, published at Strasburg in 1786, where he proposes to get rid of the allusions to the birthplace of the author of *Cynegetica* by a clumsy alteration of the text! The unqualified praise generally accorded to Oppian by critics must have been bestowed in view of the *Halieutica*, and not of the *Cynegetica*, which is altogether an inferior production. John Tzetzes calls the author a model of grace; J. C. Scaliger compares him to Virgil in harmony and elegance of style; Gaspar Barth, Conrad Gesner, and many others, never cite him except to couple his name with laudatory epithets. The two poems have generally been printed together. The only separate edition of the Greek text of the *Halieutica* is the *editio princeps*, Florence 1815. The first edition of both poems is that of Aldus, Venice, 1517, with the Latin translation of the *Halieutica* of Lorenzo Lippi, printed in 1478. The best edition is that of Schneider, containing the Greek text, accompanied with a Latin translation, and followed by the paraphrase in Greek prose which the sophist Eutecnius had made of the *Ixeutica* (another poem attributed to Oppian, but now lost), Strasburg, 1776, and Leipsic, 1813. The last edition is that of Didot, Paris, 1846. Both poems were translated into Italian by Salvini, Florence, 1728. Prior to this there were two French translations of the *Cynegetica*, one by Florent Christien, Paris, 1575; and another by Fermat in 1690. The *Halieutica* was translated into English heroic verse by Jones and others, Oxford, 1722, 8vo, with a Life of the author prefixed.

Oppian. ‖ Oppido.

OPPIDO, a town of Naples, in the province of Calabria Ultra I., 4 miles E.S.E. of Palmi. It is the see of a bishop, and is supposed to occupy the site of the ancient Mamertium. It is chiefly remarkable, however, for the great earthquake which took place here in 1783, during which several houses in the town, and an olive grove in the neighbourhood, were engulphed. Pop. 8000.

OPTICS.

History. OPTICS, from the Greek word ὀπτομαι, which signifies to *see*, is the name given to that branch of natural philosophy which treats of the nature and properties of light; of the changes which it suffers either in its qualities or in its course when transmitted through bodies, when reflected from their surfaces, or when passing near them; of the structure of the eye, and the laws of vision; and of the construction of those instruments in which light is the chief agent.

HISTORY.

The early history of optics, like that of all the sciences cultivated in ancient times, is involved in much obscurity. After the art of glass-making was discovered, lenses and spheres of glass seem to have been used as burning-glasses.

Aristophanes, B.C. 424. In Aristophanes's comedy of *The Clouds* a burning sphere is distinctly described. Pliny speaks of globes of glass which produced combustion when held to the sun.

Lactantius, A.D. 303. Lactantius informs us that a globe of glass full of water could, when exposed to the sun, kindle a fire even in the coldest weather. And it appears that globes of glass were used by the Vestal Virgins to kindle the sacred fire, and by surgeons to burn the flesh of sick persons that required to be cauterized.

Pythagoras. Among the earliest speculators on vision were Pythagoras and Plato. The former held that bodies became visible by means of particles projected from their surfaces and entering the eye, while the latter, in order to give the eye some share in the matter, supposed that something emitted from the eye met with something emitted from the object, and was again returned into the organ of vision.

Plato. The followers of Plato, however, though they had deteriorated rather than improved the conclusion of Pythagoras, were acquainted with two important facts in the science. They taught that light moved in straight lines, and that when it was reflected regularly from the surfaces of polished bodies the angle of incidence was equal to the angle of reflection.

Euclid, B.C. 300. The earliest writer on optics was Euclid, the celebrated geometer, whose treatise on the subject is still extant.[1] It consists of two books on optics and catoptrics, and proceeds on the Platonic theory, that the visual rays pass from the eye to the object, forming a cone whose apex is in the eye, and whose base is the object. He shows that the angles of incidence and reflection are equal, and that the incident and reflected rays lie in a plane at right angles to the reflecting surface; and he discusses the apparent magnitude and form of objects, and the apparent place of the images formed by reflection from plane, convex, and concave mirrors. In the 26th, 27th, and 28th theorems, he shows that the part of a sphere seen by both eyes, and having its diameter equal to, or greater or less than, the distance between the eyes, is equal to or greater or less than a hemisphere, and consequently that each eye sees dissimilar portions of the sphere, by the union of which it is seen when looked at with both eyes.[2] The book on optics contains sixty-one, and that on catoptrics, thirty-one theorems.

Aristotle, B.C. 410. As a naturalist Aristotle made some valuable optical observations. He described, with tolerable correctness, the phenomena of rainbows, halos, and parhelia. He considered the rainbow as produced by the reflection of the sun's rays from the drops of rain which gave an imperfect image of the sun; and he ascribes the light which appears in the sun's absence to the reflective power of the atmosphere. History.

The speculations of Seneca and Cleomedes derive any interest they may possess from their absurdity. Seneca noticed the magnifying power of a bottle of glass in enlarging small letters, and he observed that an angular piece of glass produced all the colours of the rainbow. Cleomedes, in his cyclical theory of motion, has given an elaborate explanation of the manner in which rays proceeding from the eye render the objects which they meet visible, but it is too stupid to demand the slightest attention. Seneca, A.D. 65. Cleomedes, A.D. 50.

Ptolemy, born A.D. 70. The science of optics may be justly considered as owing its origin to the celebrated Claudius Ptolemy, the astronomer of Alexandria, who flourished at the end of the first century. His work entitled *Ptolemæi Opticorum Sermones quinque ex Arabico-Latine versi*, was known in the time of Roger Bacon to have treated on astronomical refractions, but it had escaped the notice of philosophers, and its valuable contents were unknown until 1816, when Delambre published an analysis of it from the manuscript in the Royal Library at Paris. Montucla had, long before the discovery of the French manuscript, mentioned that a manuscript copy of Ptolemy's Optics was in the catalogue of the Bodleian Library in Oxford. This interesting manuscript, which Professor Rigaud was so kind as to examine at our request, belongs to the Savilian Library, and had been the property of Sir Henry Savile himself. As in the Parisian manuscript the first book is wanting, but it has no blank spaces like the Parisian one, and it is accompanied with a preface by the translator, containing an abstract of the work, and stating that the fifth book is imperfect. The translator mentions that the second book had been previously translated from Arabic into Latin by Amiratus Eugenius, a Sicilian, from the latest of two copies of which the new translation was made. The following abstract of this interesting work is taken from Delambre's Analysis, and from the translator's abstract as communicated to us by the late Professor Rigaud.

"The Optics of Ptolemy consists of five books. The *first* book is wanting, but from the recapitulation of it at the beginning of the second, it appears to have contained a dissertation on the relations between light and vision, founded on the idea that the visual rays issue from the eye. In the *second* book he shows that we see better with two eyes than with one, and that the object is not seen in the same place with one eye as with two. Vision, he says, is single, if the two axes of the pyramids of the visual rays are directed in the same manner on the object, but becomes double if the axes are not directed in a similar manner, and if the distance is a little less than the distance between the eyes. He next proceeds to find, geometrically, the circumstances which produce single or double images. He ascribes imperfection of sight in old men to a want of the visual virtue, which, like the other faculties, decays with the approach of age; and he states that those who have *concave* eyes see at a less distance than those who have not such eyes. Rapidity of motion, he asserts, confounds the colours on a wheel. If the colour is in the direction of a radius

[1] Euclidis *Optica et Catoptrica* nunquam antehac Græce edita. Eadem Latine reddita per Joannem Penam, Regium Mathematicum. His præposita est ejusdem Joannis Penæ de usu optices prefatio, ad illustrissimum principem Carolum Lotharingum Cardinalem, pp. 17, 18, Parisiis, 1557; or *Opera*, by D. Gregory, pp. 619, 620, Oxon. 1703.

[2] Dr Smith is of opinion that this treatise was not written by Euclid the geometer; an opinion which he rests on the number of blunders which the author has committed. (Smith's *Optics*, vol. ii. Rem. p. 16, § 93.)

History. the wheel will appear entirely of this colour, and if different colours are at different distances from the centre, these will appear on the wheel as so many concentric circles differently coloured. When, after looking long at a coloured object, we direct the eye to another, we attribute to it the colour of the first.

"In the *third* book, which treats of reflection from plane and concave mirrors, he shows, that in a plane mirror the object is seen in the perpendicular drawn from the object to the plane of the mirror and continued behind it. He mentions that objects appear smaller towards the zenith and larger towards the horizon, because in the former case we see them in a position to which we are less accustomed.

"In concave mirrors the objects appear concave, and in convex ones they appear convex, and the image is seen at the point of intersection of the reflected ray, and the line drawn from the object to the centre of the sphere.

"The *fourth* book treats of concave and compound mirrors, and of the effects of two or more mirrors. In these mirrors an object may be reflected and rendered visible by all the parts of the mirror, or by three, or two, or even one point. The image may be either on the surface of the mirror, or before the surface, or behind the eye, or behind the mirror. When the image is behind the mirror, the distance of the object from the mirror is less than that of the image. When the image is between the eye and the mirror, the distance of the object from the eye will be sometimes greater than the distance of the image from the mirror, and sometimes it will be equal to it, and sometimes less. When the object is between the mirror and the eye, it will be seen in a part different from that where it really is; and if we give it a motion in one direction, it will appear to move in the opposite direction.

"The *fifth* book is the most curious and valuable of the whole work. Ptolemy begins by explaining the experiment with the piece of money, which, when concealed behind the side of a vessel, becomes visible by filling it with water. The refraction of the visual ray in penetrating the water makes us see the piece of money out of its place, and in the prolongation of the primitive direction of the ray emitted from the eye. In order to measure this refraction at different angles, Ptolemy employs a circle divided into 360°, the inferior half of which is plunged in the water, so that the refracting surface covers one of the diameters of the circle. The centre of the circle is marked by a small coloured body, and a second similar body is fitted to one of the quadrants out of the water, and at a given distance from the vertical diameter; a third coloured body slides on the lower part, which is immersed in the water. This last body is then pushed with a rod till the eye placed on the body in the air sees all the three in a straight line. The two distances of the second and third body from the vertical diameter are thus measured on the graduated circle.

"In this manner Ptolemy obtained the results in the following table, which contains the angles of refraction from *air* to *water* from 10° up to 80° of incidence :—

Angles of incidence.	Angles of refraction.	Ratio of the sines of the angles of incidence and refraction.
0°	0° 0′	
10	8 0	1 to 0·80143
20	15 30	1 — 0·78136
30	22 30	1 — 0·76537
40	28 0	1 — 0·73037
50	35 0	1 — 0·74875
60	40 30	1 — 0·76992
70	45 0[1]	1 — 0·75249
80	50 0	1 — 0·77786

The mean of these ratios is 0·76736, differing little from the correct one, viz., 0·7486; and it is interesting to remark, that at an incidence of 40° and 50°, where the angle of refraction can be measured most accurately, the results of Ptolemy approach very near to the truth. History.

"In order to measure the angles of refraction from air into glass, Ptolemy adopted the ingenious idea of procuring a semi-cylinder of pure glass, and adjusting the diameter of it so as to coincide with the horizontal diameter of the graduated circle already described. By performing the very same experiments which he made with water, he found that there was no refraction at a perpendicular incidence; but that for every other position the angle in the air was always greater than the angle in the glass, and the refraction greater than in water. When the three bodies were placed in appearance in the same straight line they always remained there, whether the eye was placed above the glass or below it. The following are the refractions from *air* to *glass* which he obtained in this manner:—

Angles of incidence.	Angles of refraction.	Ratio of the sines of the angles of incidence and refraction.
0°	0° 0′	
10	7 0	0·70179
20	13 30	0·68255
30	20 30[2]	0·70041
40	25 0	0·65748
50	30 0	0·65270
60	34 30	0·65403
70	38 30	0·66247
80	42 0	0·67946

The mean of these ratios is 0·67386, whereas the true ratio is 0·64516; but at the angles of incidence of 40°, 50°, and 60°, the ratio is very near the true one.

"When the semi-cylinder of glass was placed on the surface of water, Ptolemy observed that the refractions from water into glass were less than any he had observed, because the difference of density between *water* and *glass* was less than between *water* and *air*. The following were the results which he obtained:—

Angles of incidence.	Angles of refraction.	Ratio of the sines of the angles of incidence and refraction.
0°	0° 0′	
10	9 30	0·95044
20	18 30	0·92774
30	27 0	0 90778
40	35 0	0 89233
50	42 30	0·88192
60	49 30	0·87804
70	56 0	0·88422
80	62 0	0·89657

The mean of these ratios is 0·90, the true ratio being 0·8760, the index of refraction for water being 1·336, and that of glass 1·525; but at the angles of incidence of 50°, 60°, and 70°, the ratio is very near the true one.

"Ptolemy now discusses the important subject of astronomical refractions, which he ascribes to the difference of density between ether and air. If the visual ray, he remarks, is stopped by an impenetrable body, it could not show us a body which is hid behind the first; and if the second becomes visible, it can only be on account of the flexion of the visual ray. This flexion takes place at its passage into a medium of different density; and the possibility of this flexion, he asserts, may be proved by the following phenomena. By observations on the stars, it was found that the parallels drawn through the apparent place of those which rise or set, are nearer the north pole than the parallels which pass through their apparent place when they are in the meridian; and the nearer the stars are to the horizon, the greater is the approach of their parallels to the pole. By observing a circumpolar star, Ptolemy found that it was nearer the pole in its lower passage across the meridian; but when it was near the zenith, its parallel became greater

[1] This is 45° 30′ in the Oxford manuscript.

[2] In the Oxford MS. this is 18° 30′. Professor Rigaud supposes the real number to have been 19° 30′.

History. in appearance, whereas in the first case it became smaller. Hence it follows that refraction raises the stars towards the zenith. In order to explain the manner in which refractions operate, Ptolemy makes use of the same figure upon which Cassini has since founded his theory. He employs almost the same reasoning in order to determine the quantity of the refraction. He remarks, that the more a star is elevated, the less will be the difference between its true and its apparent place, and that this difference will be nothing in the zenith, because a perpendicular ray experiences no flexion. He demonstrates by a figure, that in every case the refraction carries the star towards the zenith; and he states that the height of the atmosphere is unknown, but that it must begin below the sphere of the moon. From this general account of the fifth book of the Optics of Ptolemy, it will be seen that he gives a theory of astronomical refractions much more complete than that of any astronomer before the time of Cassini."

Galen, A.D. 130–218. Claudius Galen, the celebrated Greek physician, who wrote on so many other subjects than medicine, directed his special attention to the phenomena of vision. In the twelfth chapter of the tenth book of his work *On the use of the different Parts of the Human Body*, he has minutely described the phenomena which are seen when we look at solid bodies with both eyes, and with the right and left in succession. He shows by diagrams that we see dissimilar pictures of the body in each of these three modes of viewing it. "Standing near a column," he says, "and shutting each eye in succession; when the *right* eye is shut, some of those parts of the column which were previously seen by the *right* eye on the *right* side of the column, will not now be seen by the *left* eye; and when the *left* eye is shut, some of those parts which were formerly seen with the *left* eye on the *left* side of the column, will not now be seen by the *right* eye. But when we, at the same time, open both eyes, both those parts will be seen, for a greater part is concealed when we look with either of the two eyes than when we look with both at the same time."[1] In this fundamental law of binocular vision so distinctly stated, we have the grand principle of the stereoscope, namely, "*that the picture of the solid column which we see with both eyes is composed of two dissimilar pictures, as seen by each eye separately.*"

During nearly a thousand years which elapsed after the death of Galen, no progress was made in optics. Banished from Europe along with the other sciences, it found shelter in Arabia, where it was destined to receive very important accessions.

Alhazen, A.D. 1100. Alhazen, who flourished about the end of the eleventh century, was the individual who gave this fresh impulse to optical science.[2] He establishes the opinion of Pathagoras, that vision is performed by rays which proceed from the object to the eye; and he states that vision is not completed till the ideas of external objects are conveyed by the optic nerves to the brain; and after a description of the eye and its parts, he assigns to each of them the function which it performs in vision. He maintains that we see objects singly with two eyes, because we must perceive only one image when it is formed on corresponding parts of the retina. The instrument employed by Alhazen for measuring the angle of refraction, is more complex than that used by Ptolemy, and his knowledge of the refraction of the atmosphere and of fluids, is obviously inferior to that of the Alexandrian philosopher. Alhazen ascribes to refraction the twinkling of the stars, and the contraction of the diameters and distances of the heavenly bodies; and it follows, from his method of reasoning, that refraction elevated the stars towards the pole and not towards the zenith, as had been sagaciously ascertained by Ptolemy. Alhazen has described *seven* species of mirrors, and he was the first person who determined the focus of rays after reflection, when the place of the object is known. He has treated largely of optical illusions, whether produced in direct or in refracted and reflected vision; and he ascribes the size of the horizontal moon to the apparent form of the concavity of the sky, which is imagined to be more remote in the horizon than anywhere else. Alhazen likewise observed that objects were magnified when held close to the plane side of the larger segments of a glass sphere; and he has given rules, which are far from being correct, for determining the apparent size of objects when seen through such spheres. History.

Vitello, A.D. 1270. The next cultivator of optics was Vitello, whose work was first published at Nuremberg in 1535.[3] He made a series of experiments on the angles of refraction of water and glass, which apparently exceeded those of Ptolemy in correctness, the mean ratio of the sines being nearer the truth, and the ratio for each angle of incidence coinciding more accurately with the mean ratio. The following are the results he obtained with *water*:—

Angles of incidence.	Angles of refraction.	Ratio of the sines.
0°	0° 0′	
10	7 45	0·77658
20	15 30	0·78135
30	22 30	0·76537
40	29 0	0·75423
50	35 0	0·74875
60	40 50	0·74992
70	45 30	0·75904
80	50 6	0·77787

The mean of these ratios is 0·76414, whereas that obtained by Ptolemy was 0·76736, and the true ratio (the index of refraction being 1·3358), 0·7486. The results for 30° and 60° are exactly the same as Ptolemy's.

The following were the measures obtained by Vitello for *glass*:—

Angles of incidence.	Angles of refraction.	Ratio of the sines.
0°	0° 0′	
10	7 0	0·70179
20	13 30	0·68255
30	19 30	0·66761
40	25 0	0·65748
50	30 0	0·65270
60	34 30	0·65403
70	38 30	0·66247
80	42 0	0·67946

The mean of these ratios is 0·66976, whereas that obtained by Ptolemy is 0·68736, and the true ratio 0·64516.

In comparing this last table with the similar one given by Ptolemy, we cannot fail to be struck with their entire similarity, with the single exception of the angle of refraction at 30° of incidence, which Vitello makes 19° 30′, and Ptolemy, in the Paris copy, 20° 30′. Now, in the Oxford manuscript the numbers are 18° 30′; and Professor Rigaud conjectures that the real number has been 19° 30′, the same as Vitello's. Hence we cannot on any just grounds regard the measures of refraction given by the Polish philosopher as anything else than those of Ptolemy, from whom he must have borrowed them.

By comparing the two tables for water, we are inclined to make the same unfavourable supposition. The refraction for 20°, 30°, and 50° of incidence are exactly the same in both; and Vitello's measure for 70°, viz. 45° 30′, is the same as Ptolemy's in the Oxford manuscript. But this

[1] *De usu Partium Corporis Humani*, edit. Lugd. 1550, p. 593.

[2] Montucla has very incorrectly charged Alhazen with borrowing the greater part of his optics from Ptolemy. Delambre has refuted this opinion, and rendered it probable that the Arabian philosopher never saw the work of Ptolemy. What assistance he obtained from his predecessors who flourished after Ptolemy cannot now be ascertained. See *Connaissance des Tems* for 1816.

[3] This work has been very erroneously regarded as little more than a translation of Alhazen's treatise.

History. opinion is converted into certainty when we examine Vitello's table of the refractions from water into glass, in which all the measures are *identically* the same with those of Ptolemy.

In the course of his experiments, Vitello was led to observe that whenever light was reflected or refracted by transparent bodies, a certain portion of it was lost, but he does not estimate the quantity, contenting himself with the observation that bodies always appear less luminous when seen by refracted and reflected light. In treating of the cause of the rainbow, he shows that refraction is as necessary to its production as reflection, but he of course does not ascribe the colours to refraction, regarding it merely as a means of giving strength or condensation to the solar rays. He imitated the colours of the rainbow (which, like Seneca, he considers as having their origin in a mixture of the sun's rays with the blackness of the cloud) by placing a white piece of paper beneath a circular vessel of glass containing water; but he says that they are not the same colours with those of the rainbow, because they are not in the same number, and do not reach the eye after reflection. He shows that in those countries where the meridian altitude of the sun exceeds the semi-diameter of the rainbow, a rainbow cannot be seen at noon. His observations on the foci of glass spheres, on the twinkling of the stars, and on other optical phenomena, are of no value.

Passing over Archbishop Peckham's treatise on optics, entitled *Perspectiva Communis*, as containing nothing either new or important, we come to consider the claims of Roger Bacon to the invention of the microscope and the telescope. In his *Opus Majus*, which embraces his *Perspectiva* and *Specula Mathematica*, he has given an account of his speculations and inventions in optics. Dr Plott, Dr Friend, Dr Henry, Wood, Muschenbroek, Jebb, and William and Samuel Molyneux have agreed in regarding Bacon as the inventor of the telescope; while Dr Smith of Cambridge is of opinion that he wrote only *hypothetically*, and had never made any experiments with real lenses. As this is not the place to discuss this subject in a critical manner,[1] we shall content ourselves with giving a single extract respecting the telescope and microscope.

Roger Bacon, born 1214.

"Greater things than these may be performed by refracted vision. For it is easy to understand by the causes above mentioned, that the greatest things may appear exceeding small, and on the contrary; also that the most remote objects may appear just at hand, and on the contrary. For we can give such figures to transparent bodies, and dispose them in such order with respect to the eye and the objects, that the rays shall be refracted and bent towards any place we please; so that we shall see the object near at hand, or at a distance, under any angle we please. And thus from an incredible distance we may read the smallest letters, and may number the smallest particles of dust and sand, by reason of the greatness of the angle under which we may see them; and on the contrary, we may not be able to see the greatest bodies just by us, by reason of the smallness of the angles under which they may appear; for distance does not affect this kind of vision, excepting by accident, but the quantity of the angle. And thus a boy may appear to be a giant, and a man as big as a mountain, forasmuch as we may see the man under as great an angle as the mountain, and as near as we please; and thus a small army may appear a very great one, and, though very far off, yet very near us, and on the contrary. Thus also the sun, moon, and stars may be made to descend hither in appearance, and to appear over the heads of our enemies; and many things of the like sort, which would astonish unskilful persons."

Whether these remarks were the result of speculation or of actual experiment, it is not easy to determine; but in opposition to the opinion of Dr Smith, we may adduce a passage from Recorde's *Pathway to Knowledge*, printed in 1551, in which he distinctly speaks of a "glasse" used by Friar Bacon. "Great talke there is of a glasse he made at Oxford, in which men might see things that weare don, and that was iudged to be don by power of euill spirites. But *I know* the reason to be good and natural, and to be arright by geometry (with perspective as a part of it), and to stand as well with reason as to see your face in a common glass." History.

Invention of spectacles.

On the authority of various passages in the writings of Friar Bacon, M. Molyneux is of opinion that he was acquainted with the use of spectacles; and when Bacon says that "this instrument (a plano-convex glass, or large segment of a sphere) is useful to old men, and to those that have weak eyes; for they may see the smallest letters sufficiently magnified,"—we are at least entitled to conclude that the particular way of assisting decayed sight which he describes was known to him, though he may not have used his segment of a glass sphere in looking at objects separated by an interval from its plane side. But whether spectacles were in use or not in Bacon's time, it is quite certain that they were known and used about the time of his death, which happened in 1292. Alexander de Spina, a native of Pisa, who died in that city in 1313, having seen a pair of spectacles made by some other person, who was unwilling to communicate the secret of their construction, got a pair made for himself, and found them so useful, that he cheerfully made the invention public. M. Spoon,[2] to whom we are indebted for this fact, fixes the date of the invention between 1280 and 1311. Signior Redi, from whom Spoon quotes the preceding fact, states that he possesses a manuscript written in 1299, *Di Governo della Familia de Scandro di Pissozzo*, in which the author says, "I find myself so pressed by age, that I can neither read nor write without those glasses they call spectacles, lately invented, to the great advantage of poor old men, when their sight grows weak." It is stated also in the Italian Dictionary *Della Crusca*, under the head of *Occhiale* or *Spectacles*, that friar Jordan de Rivalto, who died at Pisa in 1311, tells his audience, in one of his sermons, which were published in 1305, "that it is not twenty years since the art of making spectacles was found out, and is indeed one of the best and most necessary inventions in the world." Bernard Gordon, too, a celebrated physician of Montpellier, in his *Lilium Medicinæ*, published about 1305, recommends an eye-salve as capable of making the patient read the smallest letters without spectacles; and Muschenbroek informs us that it is inscribed on the tomb of Salvinus Armatus, a Florentine nobleman, who died in 1317, that he was the inventor of spectacles.

Leonard Digges, died 1571.

Before we quit the period of Friar Bacon, we must notice a claim to the invention of the telescope which has been made in favour of Leonard Digges, an Englishman, because this claim, whatever be its amount, supports undeniably the prior claim of Bacon. The claim of Digges is founded on passages in his *Pantometria* and *Stratiotikos*. The first of these works appeared at London in 1571, and a second edition of it, edited by his son Thomas Digges, Esq., was published in 1591. The *Stratiotikos* was published in 1579 and also in 1590. In the preface to the second edition of the *Pantometria*, Thomas Digges remarks:—"My father, by his continuell painfull practices, assisted by demonstrations mathematical, was able, and sundrie times hath, by proportionall glasses, duely situate in conuenient angles, not onely discouered things farre off, read letters, numbred peeces of money, with the verye coyne and superscription

[1] We must refer our readers to a series of able anonymous letters upon this subject, published in the *Phil. Mag.* vols. xviii. xix.
[2] *Recherches Curieuses d'Antiquité*, dissert. xvi.

History. thereof, cast by some of his freends of purpose upon downes in the open fields, but also seuen miles off declared what hath beene doone in priuate places."

In the twenty-first chapter of the first book, Leonard Digges himself says,—"But marvellous are the conclusions that may be performed by glasses (mirrors) concave and convex, of circular and parabolic forms, using for multiplications of beams, sometimes the aid of glasses transposed, which, by practice, should unite or dissipate the images or figures presented by the reflection of others. By these kind of glasses, or rather frames of them placed in due angles, yee may not only set out the proportion of an whole region, yea, represent before your eye the lively image of every house, village, &c., and that in as little or great space or plan as ye will presente; but also augment or dilate any parcell thereof, so that, whereas, at the first appearance a whole toun shall present itself so small and compact together that ye shall not discover any difference of streets, yee may, by application of glasses in due proportion, cause any peculiar house or room thereof dilate and show itself in as ample form as the whole touns at first appeared, so that yee shall discern any trifle, or read any letter lying there open, especially if the sun beams may come into it, as plainly as if you were corporeally pressent, although it be distant from you as far as eye can discrie. But of these conclusions I mind not here more to introduce, having at large, in a volume by itself, opened the miraculous effects of perspective glasses."

Now it is a curious fact that Thomas Digges expressly says that his father's knowledge of optics "partly grew by the aid he had by one old written book of Bakon's Experiments, that by strange aduenture, or rather destinie, came to his hands."

In support of the opinion that the telescope was known in England more than forty years before 1609 or 1610, when it was supposed to have been invented in Holland, we may quote a passage or two from the celebrated John Dee's mathematical preface to Euclid, written at Matloke on the 9th of February 1570, the year in which it was published. Dee speaks of having seen once or twice, in company with Orontius at St Denis in 1551, "the lively image of another man in the air aloft, walking to and fro or standing still." But the most remarkable passage is that in which he speaks of the means of ascertaining the numbers of an enemy's army: "The herald, pursuivant, sergiant royall, captain, or whosoever is careful to come near the truth herein; besides the judgment of his expert eye, his skill of ordering tacticaly, the help of his geometrical instrument; ring or staffe astronomical, commodiously framed for carriage and use. *He may wonderfully help himself by perspective glasses*, in which I trust our posterity will prove more skilful and expert, and to greater purposes than in these days can be credited to be possible."

When polite learning began to revive in Europe, some of the more abstract sciences began to bē cultivated with success. Maurolycus, a teacher of mathematics at Messina, was particularly distinguished by his optical researches, of which he published an account in his *Theoremata de Lumine et Umbra* and his *Diaphanorum Partes, seu libri tres.* In the first of these works, which was completed in 1525, but not published till 1575, Maurolycus treats of the measure of light, or the illumination of bodies, and he particularly explained the curious phenomenon observed since the time of Aristotle, that when the sun shone through an aperture of any form, the figure of the aperture always appeared round; except when the sun was eclipsed, when it had the appearance of a crescent. He shows that each point of the aperture is the apex of two opposite cones of rays, one of which has the sun for its base, while the other, when cut by a plane at right angles to its axis, will produce a luminous circle, whose diameter will be proportional to the distance of the plane from the aperture. "Consequently if these images be taken at a considerable distance from the aperture, and therefore be pretty large when the aperture itself is small; since the whole image consists of a number of images, all of which are circular, the image of the sun formed by the aperture, of whatever form it be, must be circular also; and it will approach the nearer to a perfect circle the smaller is the aperture and the more distant the image." In studying the phenomena of vision Maurolycus was very successful. He shows that the crystalline humour is a lens which collects the rays which enter the eye and converges them to foci on the retina; but he does not seem to have found that these foci depict an exact image or picture of the object upon the retina. Limited, however, as this discovery was, it enabled him to ascertain the cause of *long* and *short-sightedness*, the pencils in the former case coming to a focus before they entered the retina, and in the latter at points beyond the retina. Hence, as in both these cases vision is indistinct, either from a too early or a too late convergence of the rays, he concluded that concave glasses of suitable focus would relieve the short-sighted person, and convex glasses the long-sighted person.

Maurolycus, A.D. 1525.

History.

The subject of the rainbow also occupied Maurolycus' attention. He found the diameter of the outer bow 42°, and that of the inner from 53° to 56°; but according to the theory which he adopted, namely that part of the sun's rays were reflected from the exterior of the drop, while the rest entered the drop and circulated within it by reflection along the sides of an octagon, the diameters of the bow should have been 45° and 56°. Maurolycus supposed the colours of the rainbow to be *four*, namely, *orange* (*crocus*), *green*, *blue*, and *purple*. Taking his *crocus* to be red, his enumeration in leaving out the yellow, as Dr Wollaston did more recently, show much accuracy of observation.[1] Maurolycus attempted to discover the law of refraction, but without success. He supposed that the angle of refraction was always five-eighths of the angle of incidence, which is a tolerably correct estimate in the case of glass, but quite erroneous for bodies of low and high refractive powers.

Maurolycus may be considered as the first discoverer of the aberration of figure, in so far as he observed that the rays which were incident at a distance from the axis of a transparent sphere, had their focus nearer the sphere than those which were incident nearer the axis. This happy observation was the result of his having noticed the caustic curves formed by such spheres, which he justly described as arising from the continued intersections of the refracted rays.

Baptista Porta, born 1547, died 1615.

While the Sicilian philosopher was making new and important discoveries, a celebrated Neapolitan, Joannes Baptista Porta, was endeavouring to promote the interests of science, as an ardent collector of its stores, as well as an original inquirer into its mysteries. He established an Academy of Sciences, which held its sittings in his own house, and which numbered among its members all the *virtuosi* in Naples. Each member was bound to contribute to the common stock something not commonly known, and in this way he obtained the materials for his *Magia Naturalis*, which appeared in the year 1560,[2] when he was only about fifteen years of age. This work was speedily translated into French, Hebrew, Spanish, and Arabic, and went through numerous editions in different parts of Europe. The Papal court viewed with jealousy the proceedings of a society which devoted so much energy to the spread of knowledge, and, though Baptista Porta was a Roman Catholic, the meetings of the academy were prohibited. Al-

[1] The yellow which is in the sun's direct rays is observed when the sun's rays are reflected from the sky or from clouds.

[2] A second and greatly enlarged edition was published about thirty years afterwards.

History. though Baptista Porta was well acquainted with the writings of his predecessors, yet the principal invention recorded in his *Natural Magic* is that of the camera obscura, which he seems to have brought to great perfection. He remarks, in the 17th chapter of this work, that if a small aperture is made in the shutter of a dark room, distinct images of all external objects will be depicted on the opposite wall in their true colours; and he further adds, that if a convex lens be fixed in the opening, so that the images are received on a surface at the distance of its focal length, the pictures will be rendered so much more distinct, that the features of a person standing on the outside of the window may be readily recognised in his inverted image. Baptista Porta applied his instrument to the representation of eclipses of the sun, and of hunting scenes, battles, and other events produced by moveable pictures and drawings. In this way he magnified small objects and drawings, and produced the effects of the magic lantern by the light of the sun in place of that of a lamp. He considered the eye as a camera obscura, the pupil as the hole in the window contracting and dilating with different lights, and the crystalline lens as the principal organ of vision, though he seems to have regarded it not as his convex lens, but as the tablet on which the images of external objects were formed, the cornea being, no doubt, in his estimation, the part of the eye which formed the picture. Baptista Porta was doubtless acquainted with what may be called the simplest form of the refracting telescope, namely, that in which a convex lens is the object-glass, and the eye placed six inches behind its focus, the eye-glass. He found that when his eye was thus placed behind a convex lens, he could read a letter which he could not read with his naked eye.

In another place Porta, after mentioning the effects produced by a concave and a convex lens separately, remarks, "that if you knew how to combine one of each sort rightly, you would see both far and near objects larger and more clearly." "If Porta," says Mr Drinkwater Bethune, in his admirable life of Galileo, "had stopped here, he might more securely have enjoyed the reputation of the invention, but he then professes to describe the construction of his instrument, which has no relation whatever to his previous remarks." "I shall now endeavour to show in what manner we may contrive to recognise our friends at the distance of several miles, and how those of weak sight may read the most minute letters from a distance. It is an invention of great utility, and grounded on optical principles, nor is it at all difficult of execution; but it must be so divulged as not to be understood by the vulgar, and yet be clear to the sharp-sighted." The description seems far enough removed from the apprehended danger of being too clear; and indeed every writer who has hitherto quoted it, has merely given the passage in its original Latin, apparently despairing of an intelligible translation.[1]

At a more advanced age, Baptista Porta composed another work, entitled *De Refractione Optices parte, libri novem*, and in which he treats of binocular vision. He repeats the propositions of Euclid on the dissimilar pictures of a sphere as seen with each eye and with both; he quotes from Galen the passage to which we have already referred, on the dissimilarity of the three pictures seen by each eye and by both. But having adopted the absurd opinion that we can see only with one eye at a time, he denies the accuracy of Euclid's theorem; and while he admits that the observations of Galen are correct, he endeavours to explain them on other principles. In illustrating Galen's views on the dissimilarity of the three pictures above referred to, he gives a diagram,[2] in which we recognise not only the principle but the construction of the stereoscope. It contains a view, represented by a circle, of the picture of a solid as seen by the right eye, of the picture of the same solid as seen by the left, and of the combination of these two pictures as seen by both eyes between the two first pictures. These results, as exhibited in three circles, are then explained by copying the passage from Galen, in which he requests the observer to repeat the experiments, so as to see the three dissimilar pictures when he is looking at a solid column.[3] History.

A theory of the rainbow was about this time proposed by J. Fleschier of Breslau, in his treatise entitled *De Iridibus doctrina Aristotelis et Vitellionis*, which was published in 1571. He supposes the rays to suffer two refractions,—one on entering, and the other on emerging from the drop; but after one ray had thus been separated into a coloured beam by these refractions, he supposed that this beam was reflected to the eye from another drop. Fleschier, A.D. 1571.

These views, imperfect as they are, paved the way for the true theory of the rainbow. Antonio de Dominis, archbishop of Spalatro, first broached this theory in his treatise *De Radiis Visus et Lucis*, which was published in 1611. He justly asserts that two refractions in a drop of water, and one intermediate reflection, were sufficient to bring back to the eye of the spectator the rays of light by which the bow was formed. An experiment with a globe of glass inclosing water, either suggested to him or confirmed this opinion. In following out this experiment, however, our author committed several mistakes. He explained the exterior bow by the same number of refractions and one reflection, but he supposed that the rays which formed it were returned to the eye by a part of the drop lower than that which transmitted the red of the interior bow. In addition to this mistake, he supposed that the rays which went to form one of the bows came from the upper part, and those which went to form the other bow from the under part of the sun's disc. Notwithstanding these mistakes, De Dominis is entitled to be regarded as the true discoverer of the cause of the primary rainbow. De Dominis, born 1561, died 1662.

The treatise containing these discoveries was not published till after the use of the telescope by Galileo; but Bartolo, who published it, informs us in the preface, to use the words of the author of the *Life of Galileo*, "that the manuscript was communicated to him from a collection of papers written twenty years before, on his inquiring the archbishop's opinions with respect to the newly discovered instrument, and that he got leave to publish it, 'with the addition of one or two chapters.' The treatise contains a complete description of a telescope, which, however, is proposed merely to be an improvement on spectacles; and if the author's intention had been to interpolate an after-written account, in order to secure to himself the undeserved honour of the invention, it seems improbable that he would have suffered an acknowledgment of additions, previous to publication, to be inserted in the preface. Besides, the whole tone of the work is that of a candid and truth-seeking philosopher, very far indeed removed from being, as Montucla calls him, conspicuous for ignorance even among the ignorant men of his age. He gives a drawing of a convex and concave lens, and traces the passage of the rays through them; to which he subjoins, that he has not satisfied himself with any determination of the precise distance to which the glasses should be separated according to their convexity and concavity, but recommends the proper distance to be found by actual experiment, and tells us that the effect of the instrument will be to prevent the confusion arising from the interference of the direct

[1] See "Life of Galileo," *Libr. Useful Knowl.*, p. 21, for a translation of the passage, which we have not thought worthy of insertion.
[2] This diagram is given in Sir David Brewster's *Treatise on the Stereoscope*, p. 8.
[3] *De Refractione*, &c., lib. v., p. 132; lib. vi., pp. 143–5, Neap. 1593.

History. and refracted rays, and to magnify the object by increasing the visible angle under which it is viewed."[1]

From the great liberality of his sentiments, and his conversion to the Protestant faith, this eminent ecclesiastic was obliged to leave Italy, and to take refuge in London, in 1616, where he lived some years. Having been induced to return to Italy, his imprudence exposed him to new persecutions; and having been imprisoned by Urban VIII., he died of poison in the prison of the Inquisition. Sentence was passed upon him after his death, and his body, with all his books and papers, was publicly burnt in the Campo de Fero in the year 1624.

Invention of the telescope. We now approach the time when the telescope was unquestionably invented. We have no doubt that this invaluable instrument was invented by Roger Bacon or Baptista Porta, in the form of an experiment, though it perhaps had not in their hands assumed the maturity of an instrument made for sale, and applied to useful purposes both terrestrial and celestial. If a telescope is an instrument by means of which things at a distance can be seen better than by the naked eye, then Baptista Porta's convex lens, with his eye looking at the image which it formed, and reading a letter too remote to be otherwise legible, was a real telescope; but if we give the name to a tube having a convex lens at one end, and a convex or a concave lens at the other, placed at the distance of the sum or the difference of their focal lengths, then we have no distinct evidence that such an instrument was used before the beginning of the seventeenth century.

Metius. In his *Treatise on Dioptrics*, Descartes has ascribed the invention of the telescope to James Metius, a citizen of Alkmaer, in Holland; but Huygens, in mentioning this claim,[2] says, that, "*to his certain knowledge*, telescopes were made before this at Middleburg, in Zealand, about the year 1609, either by John Lippersheim, whom Sirturus mentions, or by Zacharias (Jansen), whom Borellus makes the first inventor of them in his book *de Vero Telescopii inventore*. The telescope which they made did not exceed a foot and a half long. But much earlier than both, Joannes Baptista Porta, a Neapolitan, had delivered the rudiments of this art in his book on *Dioptrics* and *Natural Magic*, published fifteen years before telescopes appeared in our Belgium. In these books he speaks of his *specilla* as showing things placed at a distance as if they were nigh, and also of the construction of concave and convex lenses. But that he made no great progress in this art is hence evident, that in all that time it did not become famous; and that he did not discover any of those things in the heavens that were observed afterwards."

In this passage Huygens leaves the claims of his two Dutch friends on the same level; but though Borellus adopts the conclusion that Jansen was the inventor, yet it has been ingeniously suggested that Jansen's claim as the inventor of the microscope has been mixed up with the invention of the telescope, on the evidence adduced by Borellus. On this hypothesis Lippersheim is supposed to have invented the telescope by accident in 1609, and that Jansen, possessing an instrument so like it, had been able, after hearing of Lippersheim's contrivance, to make a similar instrument, without having seen the telescope of his rival.[3]

Lippersheim. Much light has been thrown on the early history of the telescope by Professor Moll, who has discussed the claims of the various competitors with much sagacity and fairness. It appears, from the official acts and journals of the States-General of Holland, still existing among the archives at the Hague, that on the 2d of October 1608 that body took into consideration a petition from Hans (John) Lippershey, a native of Wesell, and spectacle-maker at Middleburg, praying that an instrument which he had invented for seeing at a distance might be rewarded, either by granting an exclusive privilege of making it for thirty years, or an annual pension to enable him to make these instruments for Holland alone. It was resolved that a committee should communicate with the petitioner, and inquire if he could not so improve the instrument *as to enable one to look through it with both eyes.* Lippershey offered to make three telescopes of *rock crystal* for *one thousand florins* each (about L.83 each), but the committee was instructed to get him to moderate his charge, and promise never to transmit his invention to anybody. On the 6th of October a bargain was made that Lippershey should construct one instrument of rock crystal for the state, at the price of 900 florins (L.75), 300 florins to be paid down, and 600 when the telescope was completed and approved of. On the 16th December the committee report, "that they examined the instrument invented by Lippershey to see at a distance *with two eyes*, and that they approved of it." But, in reference to the exclusive privilege, they "resolved that, whereas it appears *that many other persons have a knowledge of this new invention* to see at a distance, it is expedient to refuse the prayer of the petitioner for an exclusive privilege, but that he will be commanded to make, within a certain time, two other instruments of his invention for seeing with two eyes, at the same price." These two new instruments were delivered before the 13th February 1609. History.

While these transactions were going on, Jacob Adriaansz, sometimes called Metius of Alkmaer, petitioned the States-General on the 17th of October 1608, for an exclusive privilege for a similar instrument. He was the third son of Adriaan Anthonisz, or Metius, who discovered the approximate ratio of the diameter of a circle to its circumference. His petition still exists among the manuscripts of Huygens, in the library at Leyden. He alleges that he began his researches as far back as 1606; that the invention was accidental, and when he was making other experiments; and that in 1608 when he sent in his petition, his instrument was made of bad materials. He at the same time readily admits that a spectacle-maker of Middleburg had offered before him a similar instrument to the states, which had been tried by Prince Maurice, and other persons.

Jansen. With regard to the claims of Zacharias Jansen, or rather Tansz or Zansz, they cannot be supported by any evidence; and there is reason to believe, as we shall afterwards see, that his invention of the microscope was mistaken for the invention of the telescope.[4] The following is Professor Moll's summary of the facts which he has established by authentic documents:—

"That on the 21st of October 1608, John or Hans Lippershey, a native of Wezel, a spectacle-maker of Middleburg, in Zeeland, was actually in possession of the invention of telescopes.

"That, on the 17th of October of the same year 1608, Jacob Adriaansz, sometimes called Metius of Alkmaer in Holland, also was in possession of the art of making telescopes, and that he actually made those instruments; but that either from disgust or some other reason, he afterwards concealed his invention, and thus actually gave up every claim attached to the honour of it.

"That there is little reason to believe that either Hans or his son Zacharias Zansz were also inventors of the telescope; but there is every probability that this Hans,

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[1] "Life of Galileo," *Libr. Useful Knowledge*, p. 22. [2] *Dioptrics*, p. 163–4. [3] "Life of Galileo," *Libr. Useful Knowledge*, p. 24.

[4] Professor Moll's interesting researches on the history of the telescope will be found in the *Journal of the Royal Institution*, Lond. 1831, vol. i., pp. 319, 483.

History. or John, or his son Zacharias Zansz, invented a compound microscope about 1590.

"That this Lippershey used rock or mountain crystal in the construction of telescopes, and that he is the inventor of the binoculus."[1]

Galileo's construction of the telescope, A.D. 1609. When Galileo was at Venice early in 1609, he heard rumours that an instrument which represented distant objects as if they were near, had been invented by a Dutch spectacle-maker. This rumour was confirmed by a letter which he received from James Badorere at Paris, and Galileo, who asserts that he had never seen one of the instruments, set himself to discover the principle of their construction, and to make one for his own use. It has become a question, though one of no interest, whether the Italian philosopher had actually seen one of the new instruments. We cannot hesitate for a moment in believing Galileo's assertion; and even if we confide in the statement made by Fucarius, that he had himself seen one of the Dutch telescopes, which at that time had been brought to Venice, it by no means follows that Galileo saw it. It is quite certain, indeed, that previous to the 31st August 1609, one of the new perspective glasses had been sent from Flanders to the Cardinal Borghese;[2] and Lorenzo Pignoria, on the authority of whose letter of the above date this fact rests,[3] adds, "we have seen *some* here, and truly they succeed well."

The following is Galileo's account of the matter, from a letter which he wrote in March 1610: "It is about ten months ago that it came to our ears, that a glass had been worked by a Belgian, by the help of which, visible objects, though at a great distance from the eye of the observer, may be seen distinctly. (In the Italian of the Saggiatore it is added, *ne pia aggiunto, no more was added, or this was all.*) And some experiments were related of the admirable effects of this instrument, which some believed, and others not. A few days afterwards the same was confirmed by letters of a noble Frenchman, Jacob de Badorere, from Paris; all which occasioned me to apply myself wholly to inquire into the cause of this, and to think on the means by which the invention of a similar instrument might be brought about; in which I succeeded in a short time, assisted by the doctrine of refraction: and I first procured a leaden tube (an organ pipe), at the end of which I adapted spectacle glasses, both plane on one side, the one convex on the other side, the second concave. Bringing the eye near the concave glass, I saw the objects large and near enough: they appeared three times nearer, and nine times larger than if seen with the naked eye.

"Afterwards I made another instrument, which made objects appear sixty times larger.

"Finally, sparing neither industry nor expense, I succeeded so far as to make an instrument of such excellence as to make the objects seen through it appear a thousand times larger, and more than thirty times nearer, than if seen with the natural power of the eye."[4]

Galileo's first telescope must have been made in May or June 1610. Viviani[5] says, that it was in April or May 1609 that the rumour of the invention of the telescope reached Venice when Galileo was there, and that, with this information only, Galileo returned to Padua, and succeeded in finding out the principle in the following night.

The new instrument long went by the names of Galileo's *tube*, the *perspective*, and the *double eye-glass*, the more appropriate names of telescope and microscope having been afterwards given to these instruments by Demisiano. History.

Telescopes in England, A.D. 1609. Telescopes were early and eagerly imported into England, and known by the name of *trunks* and *cylinders*; and so soon as July 1609 we find that our countryman Harriot was directing them to the lunar disc, and had begun two full drawings of that luminary, which he afterwards completed.[6] Harriot's earliest observations on Jupiter's satellites were made on the 1st October 1610, nine months after their discovery by Galileo. The earliest telescope in England must therefore have been obtained from Holland; and in a letter from Sir William Lower to Harriot, dated *the longest day of* 1610, from Traventi in Caermarthenshire, he says: "We are here so on fire with these things that I must render my request and your promise, to send more of all sorts of these cylinders. My man shall deliver you monie for anie charge requisite, and contente your man for his paines and skill. Send me so many as you think needful unto these observations: in requital I will send you store of observations. Send me also one of Galileus bookes, if anie yet be come over, if you can get them." In a letter dated July 6, 1610, Sir Christopher Heyden writes to his friend Camden: "I have read Galileus, and to be short, do concur with him in opinion, for his reasons are demonstrative; and of my own experience with one of our ordinary trunks, I have told eleven stars in the Pleiades, whereas no age ever remembers above seven, and one of these, as Virgil testifieth, not always to be seen."[7] From this and other facts, Professor Rigaud infers "that it is perfectly clear that Harriot and his friend had been in the habit of using telescopes before the discoveries of Galileo were known to them; and it appears likewise that in 1610[8] they were manufactured in England." The magnifying power of some of the telescopes used by Harriot were $\frac{6}{1}$, $\frac{10}{1}$, $\frac{12}{1}$, $\frac{15}{1}$, $\frac{32}{1}$, $\frac{60}{1}$. In a letter from Sir William Lower to Harriot, dated Traventi, 6th July 1610, he says: "I have received the perspective cylinder that you promised me, and am sorrie that my man gave you not more warning, that I might have had also the two or three more that you mentioned to chuse for me. Henceforward he shall have orders to attend you better, and to defray the charge of this an others, for he confesseth to me that he forgot to pay the worke man.

Harriot.

"According as you wished, I have observed the moone in all his changes. In the new I discover manifestlie the earthshine a little before the dichotomie; that spot which represents unto me the man in the moone (but without a head) is first to be seene. A little after, neare the brimme of the gibbous parts, towards the upper corner, appeare luminous parts like starres, much brighter than the rest; and the whole brimme along lookes like unto the description of coasts in the Dutch bookes of voyages. In the full she appears like a tarte that my cooke made me the last weeke. Here a vaine of bright stuffe, and there of darke, and so confusedlie al over. I must confesse I can see none of this without my cylinder; yet an ingenious younge man that accompanies me here often, and loves you and these studies much, sees manie of these things, even without the helpe of the instrument, but with it sees them most plainlie, I mean the young Mr Protheroe."

It is highly probable that the first Dutch telescopes had their eye-glass concave, like Galileo's, though this sup-

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[1] The binocular telescope.

[2] "Life of Galileo," *Libr. Useful Knowl.*, p. 23.

[3] The following is the passage: "We have no news except the return of his Serene Highness, and the re-election of the lecturers, among whom Signior Galileo has contrived to get 1000 florins for life; and it is said to be on account of an eye-glass like the one which was sent from Flanders to Cardinal Borghese. We have seen some here, and truly they succeed well."

[4] Moll, *Journal of the Royal Institution*, vol. i., p. 488.

[5] Viviani *Vita del Galileo*, p. 69.

[6] Rigaud's *Supplement to Bradley's Miscellaneous Works*, pp. 20, 21.

[7] Camden, *Epistolæ*, p. 129, quoted by Professor Rigaud.

[8] Before February.

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position is opposed by the traditional story of a large and inverted image of a weathercock having been seen through the earliest of them, in which case the eye-glass must have been convex. Even so late as the period when Descartes published his *Dioptrics*, which was in 1637, no other telescope but a Galilean one had been described, excepting in Kepler's *Dioptrica*, which appeared at Frankfort in 1611. In his 86th proposition he explains the theory of the telescope, and has shown how an instrument which produces the same effects might be made, by substituting for the usual concave eye-glass *one or more convex* eye-glasses. Kepler, however, does not appear to have constructed such a telescope, and Father Scheiner[1] seems to have been the first person who embodied the plan in an actual instrument, which has ever since been known by the name of the *astronomical telescope*, in consequence of the inversion of the images not being disagreeable in astronomical observations.

Astronomical telescope invented by Kepler, A.D. 1611.

Invention of the microscope.

The real inventor of the compound microscope is as little known as the inventor of the telescope. It would be in vain to inquire into the history of the single microscope, for the magnifying power of globes was known to the ancients; and no individual ambition or national partiality has endeavoured to assign the honour of inventing it to any person whatever. We agree with Professor Moll, that Zacharias Zansz or Jansen has the best claims to be considered as the constructor of the compound microscope. He seems to have made one so early as 1590, and to have presented one to the Archduke Albert of Austria, who gave it to Cornelius Drebell, who lived, as mathematician to the king, at the court of our James the First. William Boreel, the envoy to England from the States of Holland, saw in England, in 1619, and in the hands of Cornelius Drebell, the very microscope which Zansz had given to the archduke. This account of its history was given by Drebell himself. The microscope in question was 18 inches long, consisting of a tube of gilt copper 2 inches in diameter, supported by two sculptured dolphins, resting on a base of ebony, upon which the objects were placed. M. Fontana, a Neapolitan, first described the compound microscope, consisting of two convex lenses, in his work entitled *Novæ Terrestrium et Celestium Observationes*, which appeared in 1646; but claims to have made the discovery so early as 1618, though he does not adduce any evidence whatever of this fact. Huygens, on the contrary, says, "It does not appear that these microscopes were made in the year 1618, because Sirturus, who published a book that year about the origin and construction of telescopes, would hardly have been silent upon so remarkable an invention, if it had been thus known. Fontana, indeed, lays claim to it from the year 1618, in his book of *Observations*, published in 1646; but the testimony of Lyrsalis, there printed, goes no higher than the year 1625. But that my countryman Drebelius made these compound microscopes at London in the year 1621, I have often been informed by several eye-witnesses, and that he was then reckoned the first inventor of them."

Jansen.

Fontana.

This testimony of Huygens in favour of Drebell is in direct contradiction to the statement said by Boreel or Borelli, to have been made to the Dutch envoy in 1619.

Galileo the probable inventor of the microscope, A.D. 1612.

In consequence of this conflicting evidence, Galileo may be regarded as having the best claim to the invention of the compound microscope. Viviani distinctly informs us, in his *Life of Galileo*, that he was led to the invention of the microscope by that of the telescope, and that in the year 1612 he actually sent a microscope as a present to Sigismund, King of Poland. Having been dissatisfied with the performance of this instrument, he seems to have devoted himself twelve years afterwards to its improvement; and in a letter to P. Frederigo Cesi, he says that he had delayed to send him the microscope, the use of which he describes, as he had only then brought it to perfection, owing to the difficulty he experienced in making the glasses.[2] In his *Magic of Nature*, Schottus mentions a singular accident which took place with one of the newly-invented microscopes. A Bavarian philosopher, when travelling in the Tyrol, was taken ill on the road and died. The village authorities found a little glass instrument in his pocket, which happened to contain a flea fixed in the focus of the microscope. Upon looking into the eye-glass, they were struck with terror at the sight of the gigantic animal, and the remains of the poor philosopher, who was thus proved to be a sorcerer, were pronounced unworthy of Christian burial. Some bold sceptic, however, explored the mystery, and produced the giant which had alarmed them.[3]

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Discoveries of Kepler, born 1571, died 1630.

The name of Kepler, though associated principally with astronomical discovery, will ever be venerated by the cultivators of optical science. His researches, which relate principally to vision and refraction, are contained in his *Paralipomena ad Vitellionem*, published at Frankfort in 1604, and in his *Dioptrica*, already referred to. His discoveries respecting vision, though founded to a certain degree on the views of Maurolycus and Baptista Porta, are nevertheless to a great extent original. He was the first person who actually showed that distinct and inverted images of external objects are formed upon the retina, as in the camera obscura, by the foci of pencils emanating from every point of the object. He explained the phenomena of distinct and indistinct vision, and showed how that indistinctness could be removed by the use of convex and concave glasses. Although D'Alembert[4] has asserted that all optical writers before him had assumed it as an axiom that every visual point is seen in the direction of its visual ray, yet, as Dr Wells has observed, this assertion is not well founded, for Kepler had long ago maintained that objects are perceived not along the visual rays, but along lines which pass from their pictures on the retina through the centre of the eye; an opinion in which he has been followed by Dechales and Dr Porterfield, to the last of whom Dr Reid has by mistake ascribed the discovery of this law. Hence Kepler was led at once to the true theory of erect objects being seen from inverted images. This he considered as the business of the mind, which, when it judges of an impression made on the lower part of an inverted image on the retina, considers it as made by rays proceeding from the higher parts of an erect object, a necessary consequence of his opinion that objects are perceived in lines passing through the centre of the retina. In order to explain the adaptation of the eye to different distances, Kepler supposed that the ciliary processes draw the sides of the eye towards the crystalline lens, by which change the globe of the eye is elongated, and the retina placed at a greater distance from the crystalline, so as to accommodate the eye to the distinct vision of near objects.

The refraction of light in its passage through different media is treated very unsatisfactorily by Kepler. Although he failed in his attempts to discover the law of refraction, yet he arrived at certain rules for glass, which enabled him to discover many of the leading principles of convex and concave lenses. He found, for example, that below 30° of incidence, the angle of refraction was nearly two-thirds of the angle of incidence; that at 90° of incidence the angle of refraction was 42°; and that if the refracted ray fell at a greater obliquity than 42°, upon the interior surface of glass, it would be totally reflected back again into the glass at an angle equal to that of incidence. He then shows, by applying these principles, that plano-convex lenses of glass

[1] *Rosa Ursina*, 1650. [2] "Life of Galileo," *Libr. of Useful Knowledge*, p. 25. [3] Ibid., p. 27.
[4] *Opuscules Mathematiques*, tom. i., p. 265.

History. have their foci at a distance from the lens equal to the diameter of the sphere of which their convex surface is a portion, and that equi-convex lenses have their focal length equal to the radius of the sphere of which their convexities are a portion. When the lens has its surface unequally convex, he makes the focal length equal to a mean of the radii of the two spheres. The same properties being proved in reference to concave lenses, Kepler proceeds to find the focus of refracted rays, when they radiate from points at different distances from the lens. He proved also that rays issuing from the focus of a lens will emerge on the other side of it parallel; that if they issue from a point between the focus of the lens, they will diverge after refraction, while those which issue from a point beyond the focus will converge; and, finally, that when the distance of the radiant point is equal to twice the focal length of the lens, the distance of the image will be equal to the distance of the object.

In treating of the refraction of the atmosphere, Kepler remarked that the quantity of refraction would alter if the atmosphere varied in weight, and that it would be different at different temperatures.

Snellius discovers the law of refraction, A.D. 1621.

Although Tycho and Kepler made many ineffectual attempts to discover the law of refraction, yet the honour of that great discovery was reserved for Willebrord Snellius, professor of mathematics at Leyden, who died at the age of thirty-five, leaving behind him a manuscript work on the subject. The doctrine of refraction having become more important after the invention of the telescope, Snellius devoted himself to its investigation, and "after many troublesome experiments and attempts," succeeded in his research. Supposing AB to be the refracting surface of water, an object under the water at D appeared as if it were raised and seen in the line RC. He then produced RC till it intersected, at E, a line DK drawn parallel to the perpendicular MN, and he asserted that at every angle at which the object D was viewed, it would appear at E, and that CD was to CE in a given ratio, such as 4 to 3, when the refracting body was water. Now this is a true geometrical expression of the law of refraction, though the same truth may be better enunciated in other two ways. If we continue the lines CE, CD till they meet A*d*, a line perpendicular to AB, in the points *f* and *d*; then, on account of the parallels A*d*, KD, CD is to CE as C*d* is to C*f*; but ACd is the complement of the angle of refraction, and AC*f* the complement of the angle of incidence, and A*d*, A*f* are their secants. Hence it follows from Snellius's result, *that the cosecants of the angles of incidence and refraction are in a constant ratio*, which is a correct mathematical expression of the law of refraction. Again, in the triangle CDE, the sides CD, CE are to one another as the sines of the opposite angles; that is, as the sines of the angles DEC or KEC, or ECN or RCM, and of CDE or DCN; that is, *the sines of the angles of incidence and refraction are in a constant ratio*, which is the usual and most distinct expression of the law of refraction. In giving this law of Snellius, Huygens has in our opinion forgotten his usual courtesy, when he states that Willebrord Snellius did not "thoroughly comprehend his own invention," and "never imagines that the ratio was the ratio of the sines." Now we cannot conceive it possible that a man like Snellius, who was a good geometer, was ignorant of the two simple trigonometrical expressions of his geometrical law; and we do not doubt that he preferred his own for two distinct reasons. In the first place, it connects itself with the leading physical phenomena of the apparent rise of the refracted object from D to E, and by substituting CF for CD it furnishes us with a much more simple and accurate method of obtaining by projection the refracted ray from the incident one. If RF, for example, is the incident ray, we have only to divide CF into two parts, CE, EF, so that CF is to CE in the constant ratio belonging to the refracting body.

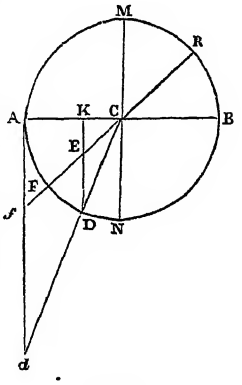

Fig. 1.

But whether we are right in this conjecture or not, it is an unquestionable truth that Snellius discovered the *true law* of refraction, though he did not express it in trigonometrical language.

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In the year 1637, about eleven years after the death of Snellius, Descartes published his *Dioptrics*, in which, without ever mentioning the name, or alluding to the labours of Snellius, he announces the true law of refraction expressed in terms of the sines, as the result of his own inquiries. As Snellius's work existed only in manuscript, it was quite possible that Descartes knew nothing of its contents; but Vossius, in his work *De Natura Lucis*, states, that the heirs of Hortensius had communicated freely to Descartes the manuscripts of that professor, among which was that of Snellius's work; and Huygens confirms this allegation when he states in his *Dioptrics* that he had himself seen the whole manuscript volume of Snellius, and had heard that Descartes had also seen it,[1] and that it was perhaps from hence that he deduced (*elicuerit*) that measure which consists in the sines. We should not have entered so minutely into this subject, had not M. Biot[2] thrown into entire oblivion the labours of Snellius, and ascribed to Descartes the undoubted discovery of what he calls "this great property of light." The same eminent philosopher likewise ascribes to Descartes the discovery that the incident and refracted rays are always in the same plane, a truth which was well known to Ptolemy, and which is clearly included in Snellius's expression of the law of refraction. In opposition to the opinion of M. Biot, we must place those of Huygens, Montucla, Bossut, Priestley, David Gregory, Smith, Hutton, Robison, Young, and Playfair; and we shall dismiss the subject after giving the admirable reasons which induced Professor Playfair to decide against Descartes. "There is no doubt, therefore," says he,[3] "that the discovery was first made by Snellius; but whether Descartes derived it from him, or was himself the second discoverer, remains undecided. The question is one of those, where a man's conduct in a particular situation can only be rightly interpreted from his general character and behaviour. If Descartes had been uniformly fair and candid in his intercourse with others, one would have rejected with disdain a suspicion of the kind just mentioned. But the truth is, that he appears throughout a jealous and imperious man, always inclined to depress and conceal the merit of others. In speaking of the invention of the telescope, he has told minutely all that is due to accident, but has passed carefully over all that proceeded from design, and has incurred the reproach of relating the origin of that instrument without mentioning the name of Galileo. In the same manner, he omits to speak of the discoveries of Kepler, so nearly connected with his own; and, in treating of the rainbow, he has made no mention of Antonio de Dominis. It is impossible that this should not produce an unfavourable impression; and hence it is that the warmest admirers of Des-

Descartes, born 1596, died 1650.

[1] Bossut is incorrect in saying that Huygens *assures us* that Descartes saw the manuscript volume of Hortensius. His words are, "*et Cartesium quoque vidisse accepimus.*" (*Dioptrica*, p. 3.)

[2] *Traité de Physique*, tom. iii., pp. 204, 205.

[3] Professor Playfair's *Dissertation* in this Work, part i., § 5.

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cartes do not pretend that his conduct towards Snellius can be completely justified."

The *Dioptrics* of Descartes consists of ten chapters. The first treats of light, the second of refraction, the third of the eye, the fourth on lenses in general, the fifth on the images formed on the bottom of the eye, the sixth on vision, the seventh on the mode of perfecting vision, the eighth on the figures which transparent bodies require to turn the rays by refraction suited to all modes of vision, the ninth on microscopes, and the tenth on the mode of polishing glasses. The inability of spherical surfaces to converge rays to one point or focus had been long known to opticians; and Kepler, though he conjectured that surfaces generated by the revolutions of the conic sections might have such a property, left the subject just as he found it. Descartes, however, has discussed it in a most ingenious manner in the eighth chapter of his *Dioptrics*. He has shown how parallel and converging and diverging rays may be brought to accurate foci by means of ellipsoidal and hyperboloidal surfaces, so that if such surfaces could be executed by opticians, all optical instruments would receive the highest degree of perfection which they could attain from the removal of spherical aberration. In order to carry this system into effect, he contrived machines for grinding elliptical and hyperbolical lenses; and in the tenth chapter of his *Dioptrics* he has given perspective drawings and descriptions of them. In the years 1627 and 1628, when he was residing at Paris, M. Mydorgius, with whom he lived on the most intimate habits, urged him to undertake the grinding of hyperbolical and elliptical lenses, and he soon became a great master of the art of glass-grinding. He found it necessary, however, to associate with himself in this undertaking an eminent artist, M. Ferrier, who, as an optical-instrument maker, was well acquainted both with the theory and the practice of his art. After many failures, a tolerably good hyperbolic convex lens was completed; but the concaves were found to be more difficult; and in consequence of M. Ferrier refusing to accompany Descartes to Franeker, and having occasioned him much needless expense in the erection of his laboratory, a quarrel took place, and the great practical object which they had in view was for a while abandoned. Descartes, however, was sanguine in his expectations, and not aware that there was another aberration more difficult to overcome than that of spherical figure, he expected to be able to make the greatest discoveries in the heavens by means of his new lenses. With the assistance of M. Huygens, the father of the celebrated philosopher, he induced some Dutch artists to renew the attempts of Ferrier; but these and his subsequent endeavours to construct such lenses have failed, though we cannot allow ourselves to think that the attempt is a hopeless one.

Descartes made some interesting observations upon vision, particularly on the method by which we judge of the distances and magnitudes of objects; but his principal discovery in physical optics relates to the theory of the rainbow. He discovered the true cause of the exterior rainbow; and in his *Traité des Meteores*, he proves that it was produced by two refractions, and two intermediate reflections within the drop, thus explaining most satisfactorily the faintness of its illumination, and the inversion of its colours. He has clearly shown also, why the interior bow is 42° in diameter, while the exterior one is 52°; though he did not understand the true origin of the colours. We regret to add, that Descartes gives his explanations of both the interior and exterior bows without ever mentioning the name of Antonio de Dominis, who was the real discoverer of the cause of the rainbow; and our regret is increased when we are compelled to add, that M. Biot has, contrary to the opinion of all philosophers, given his aid to Descartes in depriving the Italian philosopher of the only discovery which has immortalized his name.[1] History.

The science of optics is under considerable obligations to Christopher Scheiner, a Jesuit, and professor of mathematics at Ingolstadt. He completed the theory of vision in so far as he proved by direct experiment that the pictures of external objects were distinctly delineated on the retina. By paring away the coats from the back of the eyes of sheep and oxen, and also the human eye, he made the inverted pictures distinctly visible, and exhibited the experiment publicly at Rome in 1625. In his work entitled *Oculus*, published in 1652, he speaks of the great resemblance of the eye to the camera obscura, and gives various contrivances for erecting the images. He adopts the theory of Kepler respecting the visible direction of objects, and he observed the interesting fact that the pupil of the eye is dilated in viewing distant, and contracted in viewing near objects. In measuring the refractive powers of the humours of the eye, he makes that of the aqueous humour differ little from that of water, and that of the crystalline humour differ little from that of glass, ascribing to the vitreous humour an intermediate refractive power. By tracing the progress of the visual rays through all the humours of the eye, he demonstrates that the retina, and not the crystalline lens, is the seat of vision; and he describes some interesting experiments respecting vision through one or more small apertures. We owe also to Scheiner the interesting experiment of exhibiting on the wall of a darkened room the disc of the sun with all its spots by means of a telescope. Christopher Scheiner, born 1575, died 1650.

A new and very interesting branch of optics had begun to excite the attention of philosophers, namely, that of the double refraction of light. Erasmus Bartholinus, a physician at Copenhagen, and the author of several excellent works on geometry, received from some Danish merchants that frequented Iceland "a crystal stone like a rhombic prism, which, when broken into small pieces, kept the same figure." With this substance which was called *Iceland spar*, from its locality, Bartholinus made a number of experiments both chemical and optical, and he has published an account of the optical results which he obtained in a small volume which appeared at Copenhagen in 1669, under the title of *Erasmi Bartholini Experimenta Crystalli Islandici, Disdiaclastici quibus mira et insolita Refractio detegitur*, and is dedicated to Frederick III., King of Denmark. In *seventeen* experiments and *twelve* propositions this able and sagacious philosopher has presented us with an excellent summary of the more prominent phenomena of double refraction. He has shown that Iceland spar has the property of double refraction,—that is, of giving two images of all objects seen through it, whether its faces are parallel or inclined, like those of a prism; that the incident light is equally divided between these two pencils; that one of these refractions is performed according to the law of Snellius, the ratio of the sines being as 1 to 1·667, but that the other is performed according to an extraordinary law which had not previously been observed by philosophers. He observed also a position in which the object appears six-fold, but he did not discover that this took place only in some specimens which were composite or irregular crystals. Double refraction of light discovered by Bartholinus, A.D. 1669.

These discoveries of Bartholinus having been communicated to the Royal Society of London, and printed in No. 67 of their *Transactions*, they attracted the notice of Christian Huygens, a celebrated Dutch philosopher of the finest genius and the highest attainments. Having given a new theory of refraction, he wanted to repeat Bartholinus's Discoveries of Huygens, born 1629, died 1695.

[1] In his *Optics*, book ix., p. 147, Sir Isaac Newton gives almost the whole merit of the explanation of the rainbow to De Dominis. He says, "The same explication Descartes hath pursued in his *Meteors*, and *mended that of the exterior bow*."

History. experiments, principally with the view of ascertaining if they opposed any difficulties to that theory. His work on this subject, entitled *De l'estrange Refraction du Cristal d'Islande*, which forms the 5th chapter of his *Traité de la Lumière*, was written in 1678, and was read to Cassini, Roemer, and De la Hire, and to several other members of the Royal Academy of Sciences, which he had been invited to join by the liberality of the French king; but it was not published till 1690, when he was resident at the Hague. After giving Bartholinus the credit of having discovered some of the principal phenomena of double refraction, he describes the general properties of Iceland spar in forming two images of objects, and he shows that all the phenomena are related to the axis, or that diagonal of the rhomb, in the direction of which the crystal has no double refraction. He proves that the double refraction, or separation of the two images, gradually increases as the inclination of the refracted ray to the axis increases, and becomes a maximum in a plane at right angles to the axis. In the four preceding chapters of his *Traité de la Lumière* he had explained all the phenomena of reflection and refraction upon a new theory, in which he supposed light to be produced in the same manner as sound, by means of undulations propagated in an elastic ethereal medium; a hypothesis revived by Euler and extended by Dr Young, and now almost universally embraced under the name of the "undulatory theory." In applying the same theory to explain the phenomena of double refraction, he supposes the ray produced by the *ordinary* refraction of the medium to be produced by *spherical* undulations propagated through the crystal, while the ray formed by the *extraordinary* refraction is produced by *spheroidal* undulations, the ratio of the two refractions determining the form of the generating ellipse. Huygens then proceeds to show that this theory affords, by calculation, results agreeing very exactly with those which he had obtained by direct experiment. This discovery is perhaps the most splendid which has occurred in the history of optical science.

Discovery of the polarization of light. When Huygens had finished his researches on double refraction, he discovered what he calls a "wonderful phenomenon,"[1] and, though he acknowledges that we cannot find the cause of it, yet he thinks it proper to indicate the phenomenon that others may inquire into it. This discovery is that of the *polarization of the light* which forms the two pencils of Iceland spar, and he confesses that he must add to this theory other suppositions in order to explain it, though he thinks that a theory confirmed by so many proofs will still preserve its plausibility (*vraisemblance*). Huygens had naturally supposed that the light which composed the two pencils was like all other light, but upon transmitting the two rays formed by one rhomb of calcareous spar through another rhomb, he was astonished to perceive that when the two rhombs were similarly placed as if they had formed one larger one, neither of the rays suffered double refraction in passing through the second rhomb, the ordinary ray from the first being only ordinarily refracted by the second rhomb, and the extraordinary ray only extraordinarily refracted. The same thing took place when one of the rhombs,—the second, for example,—was turned round 90°, with this difference, that the ordinary ray of the first rhomb suffered only extraordinary refraction, and the extraordinary ray only ordinary refraction from the second rhomb. But in all other positions of the second rhomb, excepting these two rectangular ones, the ordinary and extraordinary rays of the first rhomb were each divided into two by the second rhomb; so that there were now *four* rays, sometimes of equal, but generally of unequal brightness, and such that the light of all the four never exceeded that of the single ray incident on the first rhomb. History.

Huygens discovered also the double refraction of quartz, or rock-crystal, but he committed a great mistake in supposing that its double refraction was regulated by an entirely different law, the light being in this case *propagated through it in two spherical waves, one of which was a little slower then the other.*[2] This result he mentions in his preface as having been obtained after he had read his work to his colleagues in the Academy of Sciences. It is, however, founded on an incorrect observation, as the extraordinary refraction of rock-crystal is produced by spheroidal undulations like that of Iceland spar, with this difference only, as afterwards discovered by M. Biot, that the spheroid is a prolate one.

Even if Huygens had not immortalized his name by these great discoveries, his treatise on *Dioptrics* and on *Halos*, and his construction of refracting telescopes of immense size, would have given him the highest reputation. His treatise on *Dioptrics*, which was not published till 1703, among his posthumous works, and which he had begun to prepare at an early period of his life, was particularly admired by Sir Isaac Newton. It contains a copious explanation of the properties of lenses of all forms; and their spherical aberration is treated with much perspicuity, having previously, in the 6th chapter of his *Traité de la Lumière*, published an interesting discussion respecting the figures of transparent bodies for refracting and reflecting light to a single focus. The subject of vision, and the method of assisting long and short sighted persons by lenses is ably discussed, and nearly the latter half of the work is devoted to the theory of telescopes, telescopic eye-pieces, and microscopes.

Many of these theoretical views Huygens submitted to the test of experiment. Having acquired great expertness in the art of grinding lenses, he executed refracting telescopes 12 and 24 feet in focal length, and afterwards one of 120 and another of 123 feet, with which he discovered Saturn's ring and the fourth of his satellites. These two last object-glasses he presented to the Royal Society; but as it was impracticable to use tubes of such enormous length, Huygens contrived a method of mounting them without tubes at the top of a long pole. The practical knowledge which he had thus acquired, was published along with his *Dioptrics* in a work entitled *Commentarii de formandis poliendisque vitris ad Telescopia*, a considerable part of which was published by Dr Smith in his *Optics*. Among his posthumous works appeared his *Dissertatio de Coronis et Parheliis*, a work of great merit, in which he ascribes these phenomena generally to crystals of ice in the upper atmosphere, and a translation of the whole of which Dr Smith has published in the first volume of his *Optics*.

James Gregory, born 1638, died 1675. Among the eminent men who gave an impulse to optical discovery, we must assign a considerable place to our countryman James Gregory. This eminent mathematician, in confirming the experiments of Vitello and Kircher on the angles of refraction, discovered the true law which had previously been found by Snellius. He made the refractive power of water 1·3347, which coincides *exactly* with that of the middle ray between the lines D and E of Fraunhofer. Having discovered, before the publication of this work, that Descartes' *Dioptrics* contained the law of refraction, he mentions the circumstance, and ascribes his being unacquainted with that work to the "want of new mathematical books" in the library of the college of Aberdeen. Although Bap- Invention of the reflecting telescope tista Porta appears to have made the nearest approach to the invention of the Newtonian reflecting telescope, or

[1] "Une *phénomène merveilleux*, que j'ay decouvert après avoir écrit tout ce que dessus." (*Traité de la Lumière*, p. 88.)

[2] *Traité*, &c., §§ 20, 21. "Cette double refraction sembloit demander une double émanation d'ondes de lumière, *toutes deux sphériques*, (car les deux refractions sont regulières) et les unes seulement un peu plus lentes que les autres."

History. rather microscope, yet his experiment excited no notice, and no instrument could be said to have been invented.

Gregorian telescope. James Gregory, however, has described what is now known by the name of the Gregorian Reflecting Telescope, at the end of his *Optica Promota*, published in 1663. It consisted of a parabolic concave mirror perforated at the centre, and having in front of it a small concave elliptic speculum, at a distance a little greater than the sum of their focal lengths. The parallel rays emitted by a remote object formed an image of that object in front of the great mirror, and in its focus; and in the conjugate focus of the small speculum, behind the great speculum, there was formed another image of the object, which was magnified by an eye-glass. In 1664 Messrs Rives and Co., English opticians, attempted to construct a 6-feet Gregorian telescope, under the superintendence of its inventor, but, after a rough trial of it, Mr Gregory, not aware of the nice adjustments which it required, conceived that the figure of the speculum was defective, and, being on the eve of going

Newtonian telescopes. abroad, he never even made a tube for the mirrors. Stimulated by the failure of his friend, Newton "altered," as he says, "the design of the instrument," and "placed the eye-glass at the end of the tube rather than at the middle;" and therefore he was obliged to reflect the rays to a side by an oval plane speculum. Sir Isaac actually constructed one of these instruments with his own hands, and described it in a letter to a friend, dated the 23d February 1668–9. The aperture of the speculum was 1 inch, its focal length *six* inches, the eye-glass, which was a plano-convex lens, about $\frac{2}{3}$ths of an inch in focal length, and the magnifying power 39 times. He considered it as equal to a 3 or 4 feet refractor, and it showed distinctly the four satellites of Jupiter and the phases of Venus.[1] Encouraged by his success, he completed another telescope in 1671, which was better than the first, and which is preserved in the library of the Royal Society. The next Newtonian reflecting telescope of any importance was executed by Mr John Hadley in 1719 or 1720, with a speculum 6 inches in diameter, and 5 feet in focal length; but for a long time the Gregorian form was the most popular in England. About

Cassegrainian telescope. 1672 M. Cassegrain substituted a convex speculum for the small concave one of Gregory, which had the advantage of shortening the tube of the telescope without diminishing the power of the instrument.

Other claimants have arisen for the honour of inventing the reflecting telescope. Father Mersenne, in a letter to Descartes in 1637, suggested the idea of using concave mirrors in reflecting telescopes; but Descartes endeavoured to convince him that his views were not likely to succeed. At a later period Fontenelle, in the *History of the Academy of Sciences* for 1700, has very recklessly ascribed the invention of this instrument to Father Zucchi, an Italian Jesuit, who published at Lyons, in 1652, a volume entitled *Optica Philosophica*. In this work he says that he thought of substituting concave specula for object-glasses, and having found a concave metallic mirror in a cabinet of curiosities, he applied to it a concave eye-glass, and observed with it celestial and terrestrial objects. As no small speculum was used in this combination, it was neither a Newtonian, Gregorian, nor Cassegrainian telescope; and if Zucchi conceived himself the inventor of a reflecting telescope, why did he conceal it till 1652, and why did he not get a real speculum made to give his idea a fair trial?

Grimaldi discovers the inflection of light; born 1619, died 1663. Among the discoveries of the seventeenth century, that of the inflection of light ranks among the most important. This addition to physical optics was made by Francis Maria Grimaldi, an Italian Jesuit, who published an account of it in a work entitled *Physico-mathesis de Lumine, Coloribus, et Iride, aliisque annexis*, which was published at Bologna in 1665, two years after his death. Introducing a ray of the sun's light into a dark room, and through a very small aperture, he remarked that it formed a cone of light in which all bodies had their shadows larger than if the rays passed in straight lines by their edges. Round these shadows he noticed three coloured fringes becoming narrower as they were farther from the body; and in strong light he observed similar coloured fringes, varying from two to four, according to the distance of the shadow from the body. Hence our author concluded that light is bent from its rectilineal path in passing by the edges of bodies.

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When he admitted the light through two small apertures, so near each other that the one luminous cone did not penetrate the other till at a considerable distance from the apertures, he observed that the rays so interfered with one another as to render the spot illuminated by their *united light more obscure than when it was illuminated by either of them singly*. This extraordinary result is announced in the following proposition: "That a body actually illuminated may become more obscure by adding a new light to that which it already receives,"—and may be regarded as the first discovery of the interference of light.

Dr Hooke. born 1635, died 1703. Dr Robert Hooke, one of the most ingenious and able men of the century which he adorned, not knowing of the discovery of Grimaldi, communicated to the Royal Society in 1672 an account of "the discovery of a new property of light not mentioned by any optical writers before him." In a subsequent communication in 1675, he draws the following conclusions from his experiments:—1. There is a *deflection* of light, differing both from reflection and refraction, and seeming to depend on the unequal density of the constituent parts of the ray, whereby the light is dispersed from the place of condensation, and rarified, or gradually diverged into a quadrant. 2. This deflection is made towards the superficies of the opaque body perpendicularly. 3. Those parts of the diverged radiations which are deflected by the greatest angle from the straight or direct radiation are the faintest, and those that are deflected by the least angles are the strongest. 4. Rays cutting each other in one common foramen do not make the angles at the vertex equal. 5. Colours may be made without refraction. 6. The diameter of the sun cannot be taken with common sights. 7. The same rays of light, falling upon the same point of an object, will turn into all sorts of colours by the various inclination of the object. 8. Colours begin to appear when two pulses of light are blended so well, and so near together, that the sense takes them for one."

We owe also to Dr Hooke the first accurate experiments that were made on the subject of thin plates, which, we believe, had been first observed by Mr Boyle.[2] He investigated the leading phenomena as exhibited in the colours of the soap bubble, and between two plates of glass pressed together. He discovered that the colours depended upon certain thicknesses of the thin plates; but he failed in determining the relation between given thicknesses and given colours. He succeeded in splitting mica into plates of extreme tenuity, so as to give the most brilliant colours, one giving a *yellow*, another a *blue*, and the two together a *deep purple*. In his *Micrographia*, printed about seven years before any of Newton's experiments were made on the same subject, Dr Hooke has published the following remarkable explanation of these phenomena, which coincides in a singular manner with that which is now universally received:—"It is most evident (says he) that the reflection from the under or further side of the body is the principal cause of the production of these colours. Let the ray fall obliquely on the thin plate, part thereof is reflected back

[1] Brewster's *Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton*, vol. i., pp. 45–52.
[2] *Experiments and Observations upon Colours*, 1663.

History. by the first superficies,—part refracted to the second surface, whence it is reflected and refracted again. So that after two refractions and one reflection there is propagated a kind of fainter ray; and by reason of the time spent in passing and repassing, this fainter pulse comes behind the former reflected pulse; so that hereby (the surfaces being so near together that the eye cannot discriminate them from one) this confused or duplicated pulse, whose strongest part precedes, and whose weakest follows, does produce on the retina the sensation of a yellow. If these surfaces are further removed asunder, the weaker pulse may become coincident with the reflection of the second or next following pulse, from the first surface, and lag behind that also, and be coincident with the third, fourth, fifth, sixth, seventh, or eighth; so that if there be a thin transparent body, that from the greatest thinness requisite to produce colours does by degrees grow to the greatest thickness,—the colours shall be so often repeated, as the weaker pulse does lose paces with its primary or first pulse, and is coincident with a subsequent pulse. And this, as it is coincident or follows from the first hypothesis I took of colours, so upon experiment have I found it in multitudes of instances that seem to prove it."

Galileo and the philosophers of the Academia del Cimento had proposed to measure the velocity of light by means of a base on the surface of the globe; but such an attempt was utterly hopeless, and it was only in a wider range that this problem could be solved. Baffled in finding an explanation of some irregularity in the emersion of the first satellite of Jupiter, Cassini and Roemer had concluded that it depended on the distance of Jupiter from the earth, and that in order to explain it, it was necessary to suppose that the light of the satellite required ten or eleven minutes to move across the earth's orbit. This happy idea seems to have first occurred to Cassini; but he speedily abandoned it, while Roemer pertinaciously cherished the hypothesis, and at last immortalized himself by demonstrating in the most rigorous manner that light moves through the diameter of the earth's orbit, a distance of 190 millions of miles, in eleven minutes.

Roemer, born 1644, died 1710.

Passing over the valuable researches of Tschirnhausen, a Saxon nobleman, on caustic curves, which had been previously discovered, and the discoveries of Mariotte and De la Hiré, respecting the seat of vision, which have not terminated in any satisfactory conclusions, we are brought to one of the most brilliant periods of optical discovery.

Discoveries of Newton, born 1642, died 1727.

In the year 1665 Sir Isaac Newton, when only twenty-three years of age, bought three prisms; but he does not seem to have made any particular experiments with them. In 1666, however, he bought another, with which he proposed to repeat Grimaldi's experiment on the elongation of the sun's image produced by the prism. In the course of this and the two or three subsequent years, he made and perfected his great discovery of the *different refrangibility of light*, which he communicated to the Royal Society on the 6th of February 1672, having, on the 18th of January, announced it as "the oddest if not the most considerable detection which hath hitherto been made in the operations of nature." Having found that refraction could not be produced without colour, he was led to direct his attention to the perfection of the reflecting telescope, and produced the instruments which we have already mentioned. Another result of this discovery was the completion of the theory of the rainbow, the origin of the colours of which had hitherto perplexed philosophers. History.

The next optical discovery made by Sir Isaac Newton related to the *colours of thin plates*, or of thin transparent bodies, such as the soap bubble. We have already seen that Dr Hooke had made some progress both in observing the phenomena and in investigating the cause of such colours; but it is to Newton that we owe an elaborate analysis of the subject. In a letter from Sir Isaac to Dr Hooke, dated 5th February 1676, he acknowledges that the latter had previously observed "the dilatation of the coloured rays by the obliquation of the eye, and the opposition of a black spot at the contact of two convex glasses, and at the top of a "water bubble" (soap bubble). In the course of his experiments on thin plates Newton was led to the discovery of the colours of thick plates; and he devised a theory for explaining both classes of phenomena, known by the name of the theory of fits of easy reflection and transmission. This theory, remarkable for its ingenuity, is now no longer an expression of the phenomena, and has given way to the theory of undulations, which Hooke had the sagacity to anticipate as affording the true cause of the colours of thin plates.

Early in 1676 Newton communicated to the Royal Society his *Theory of the Colours of Natural Bodies*, in which he ascribes all the varieties of colour exhibited in nature to the circumstance "that the transparent parts of bodies, according to their several sizes, reflect rays of one colour and transmit those of another, on the same grounds that thin plates or bubbles do reflect or transmit those rays."

Sir Isaac Newton's experiments on the inflection of light were never finished by their author. His observations were limited, and his theory incorrect; and indeed it was only from the hands of those who adopted the undulatory system that a true explanation of the phenomena could be expected.

The experiments of our author on the refractive powers of bodies, from which he anticipated that the diamond "was probably an unctuous substance coagulated," have on this account been regarded with high favour; while his few observations on the double refraction and polarization of light have almost disappeared from the history of optics.[1]

Achromatic telescope.

The next great step in the history of optical discovery is the invention of *achromatic telescopes*, or telescopes which are free from colour. When Sir Isaac Newton found that he could not produce refraction without colour, he abandoned the improvement of the refracting telescope as hopeless, and devoted himself to the construction of reflectors. The opinion at which he had arrived respecting the impracticability of refracting light without colour was, however, an erroneous one, which he had deduced from an incorrect observation of the relative length of the prismatic spectra formed by different bodies when the mean refraction was the same. In less than two years after Newton's death—namely, in 1729—Mr Chester More Hall, of More Hall in Essex, was led by the study of the human eye, which he erroneously conceived to be achromatic, to consider the possibility of constructing a telescope by an analogous combination of media. After many experiments, he found two kinds of glass capable of producing, by their combination, refraction without colour.[2] About 1733 he completed several such object-glasses, which, with a focal length of 20 inches, bore an aperture of more than 2½ inches, one of

Mr More Hall.

[1] We must refer our readers, for a full and elaborate account of Newton's optical discoveries, to Brewster's *Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton*, vol. i.

[2] Mr Hall might have got this hint from David Gregory's *Catoptrics*, published at Edinburgh in 1713. "But if," says he, "on account of physical difficulties in grinding and polishing proper specula, we should still use lenses, *it would perhaps be useful to employ media of different density to compose the object-glass*, as we see done by nature in the structure of the eye, where the crystalline humour (of almost the same refractive power as glass), is joined by nature, who does nothing in vain, with the aqueous and vitreous humours (not unlike water in their refractive power), to paint the image as distinctly as possible in the bottom of the eye." (Gregory's *Catoptrics*, prop. xxiv., scholium.) Dr Brown's translation of the preceding passage is very incorrect.

History. which was long afterwards in the possession of the Rev. Mr Smith, of Charlotte Street, Rathbone Place, and was found to be achromatic. Another of Mr Hall's telescopes was in the possession of Mr Ayscough, optician in Ludgate Hill, in 1754. Mr Hall, however, kept his invention a secret; none of his instruments were either sold or exhibited for sale, and those into whose hands they fell do not seem to have discovered either their principle or their value.

Dollond. A.D. 1757. Without calling in question the merits of Mr Hall, we must do justice to those of Mr John Dollond, an undoubted inventor of the achromatic telescope, who, unacquainted with the instruments of Mr Hall, proceeded step by step till, in 1757, he invented and constructed the achromatic telescope. To this eminent individual, and the other members of his family, we owe the construction of many of the finest instruments by which the science of astronomy has been so much promoted. Mr Peter Dollond, the son of John Dollond, first suggested and used the triple object-glass, in which a better correction of the spherical aberration was effected, by placing the concave flint glass between two convex lenses of crown glass.

The mathematical world owe many obligations to Euler, Clairaut, D'Alembert, and Boscovich, for their able investigations of the theory of achromatism, but their investigations did not prove of any practical value; and it has been justly stated by Sir John Herschel, "that from all the abstruse researches of Clairaut, Euler, and D'Alembert, and other celebrated geometers, nothing hitherto has resulted beyond a mass of complicated formulas, which, though confessedly exact in theory, have never yet been made the basis of construction for a single good instrument, and remains therefore totally inapplicable, or at least unapplied in practice."[1]

Photometry. No attempt had hitherto been made to measure the intensity of different lights emanating either directly from luminous bodies, or when transmitted through or reflected from different bodies. This subject, to which the name of Photometry has been given, was begun by Huygens and P. F. Marie, who describes an instrument called a *lucimeter;* but it is to M. Bouguer and M. Lambert that we owe the most scientific and complete investigation of this class of facts.

Bouguer, born 1698, died 1758. Bouguer's earliest experiments were published in 1729, in his *Optical Essay on the Gradation of Light*, which was republished in 1760, much augmented and improved, under the title of *Traité d'Optique sur la Gradation de la Lumière.*

Lambert, born 1728, died 1777. Bouguer was followed in this inquiry by M. Lambert, an able German mathematician, who published an account of his researches at Augsburg in 1760, in a duodecimo volume of 547 pages, entitled *Photometria seu de Mensura et Gradibus Luminis, colorum et umbræ.* It is divided into seven parts:—1. On the modifications and degrees of direct light, and of its brightness and illuminating power; 2. Experiments and calculations on the modifications of light depending on transparent bodies, but chiefly glass; 3. Experiments and calculations respecting the modifications of light depending on the opacity of bodies; 4. Calculations and experiments on the sense of light, and its apparent brightness; 5. On the dispersion of light passing through diaphanous media, chiefly the earth's atmosphere; 6. Calculations respecting the illumination of the planetary system; and 7. On the modifications and degrees of heterogeneous and relative light, or the light of colours and shadow.

Sir William Herschel, born 1738, died 1822. Passing over the minor labours of Porterfield, Turner, Mazeas, Dutour, Buffon, Scheiffer, Darwin, Melvill, Mitchell, and others, we come to the period of Sir William Herschel. Since the discovery of the belts and nearest satellites of Saturn, no discovery of any importance had been made respecting the natural history of the heavens. At the age of thirty-six, when Sir William was residing at Bath, he devoted much of his time to the construction of telescopes; and the following account of his progress is too interesting to be given in any other language than his own,—"When I resided," says he, "at Bath, I had long been acquainted with the theory of optics and mechanism, and wanted only that experience which is so necessary in the practical part of these sciences. This I acquired by degrees at that place, where, in my leisure hours, by way of amusement, I made for myself several 2-feet, 5-feet, 7-feet, 10-feet, and 20-feet Newtonian telescopes, besides others of the Gregorian form, of 8-inches, 12-inches, 2-feet, 3-feet, 5-feet, and 10-feet, focal length. My way of doing these instruments at that time, when the direct method of giving the figure of any one of the conic sections to specula was still unknown to me, was to have many mirrors of each sort cast, and to finish them all as well as I could, then to select by trial the best of them, which I preserved; the rest were put by to be repolished. In this manner I made no less than two hundred 7-feet, one hundred and fifty 10-feet, and about eighty 20-feet, not to mention those of the Gregorian form, or of the construction of Dr Smith's reflecting microscope, of which I also made a great number. My mechanical amusements went hand in hand with the optical ones. The number of stands I invented for these telescopes it would not be easy to assign. I contrived and delineated them of different forms, and executed the most promising of the designs. To these labours we owe my 7-feet Newtonian telescope stand, which was brought to its present convenient construction about 1778."

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By means of these instruments, with which he surveyed the heavens with unwearied diligence, he discovered the planet Uranus, with six satellites, two new satellites circulating round Saturn, the quintuple belt and double ring of the same planet, and various other astronomical phenomena of the highest interest. In 1783 he finished a 20-feet reflector, with an aperture of $18\frac{7}{10}$ inches, and formed the design of constructing a still larger instrument. On the recommendation of Sir Joseph Banks, his Majesty George III. agreed to defray the expense of a large telescope, and under his munificent patronage, which has never since been imitated by his successors, Sir William began in 1785, and completed, on the 27th August 1789, a reflecting telescope 40 feet in focal length, having its great speculum *four feet* in breadth, $3\frac{1}{2}$ inches thick, and weighing, when newly cast, 2118 lb. On the 28th of August, the day after this gigantic instrument was erected, Sir William discovered a new satellite of Saturn, and in the same year another satellite, both of which were nearer the body of the planet than the other five discovered by Huygens and Cassini. In this manner the telescope, which was a toy in the hands of Galileo, became with Sir William Herschel a vast machine, carrying the observer himself, and directed and moved by appropriate mechanism.

Dr Blair, A.D. 1787, died 1829. An improvement in the achromatic telescope, of great value, though not yet brought into practical use, was made by Dr Robert Blair. Although in the achromatic telescope composed of crown and flint glass, the colour was as completely corrected as it was possible to do with such lenses, yet it had long been observed that there were residual colours, which formed what are called a secondary spectrum, and which arise from the coloured spaces in the spectrum, produced by crown glass not having the same size as those in a spectrum of equal length produced by flint glass. Various attempts had been made in vain to obtain other substances, in which this *irrationality*, as it was called, of the coloured spaces did not exist; and Dr Blair was hence led to attempt the removal of the secondary spectrum by other

[1] *Phil. Trans.*, 1821, p. 222.

History. means. The plan which he adopted was the following:—He made each lens of his compound object-glass achromatic, but in such a way that the secondary spectrum produced by the one should be corrected by the secondary spectrum produced by the other. Such an object-glass required two fluid media and three lenses of glass, and Dr Blair succeeded in constructing them so as to be perfectly free from all secondary colour. In the course of his experiments, however, he was fortunate enough to discover that the muriatic acid mixed in proper proportions with metallic antimony, or butter of antimony, as it was called, gave a spectrum in which the colours had exactly the same proportion as crown glass; and hence, by inclosing this fluid between two lenses of crown glass, the one next the object being plano-convex and the other a meniscus, he obtained an object-glass in which the rays of different colours were bent from their rectilineal course with the same equality and regularity as in reflections. To such an object-glass he proposed to give the name of *aplanatic*, to indicate the entire removal of all aberration. Dr Robison informs us that one of these telescopes, which did not exceed *fifteen inches* in length, equalled in all respects, if it did not surpass, the best of Dollond's achromatic telescopes *forty-two inches* long. After the death of Dr Blair, his son, Mr Archibald Blair, attempted in vain to produce instruments of the same perfection. Had this young man lived, he might have executed something better, but he was cut off at an early age, and has left to the Royal Society of Edinburgh an account of his father's methods, which we hope may prove useful to science.

Dr Thomas Young, born 1773, died 1829.

Hitherto the undulatory theory of light, as proposed by Huygens, and supported by Hooke and Euler, had met with few adherents; and the reputation of Newton had given to the theory of emission an adventitious authority to which it was not entitled. Dr Young, however, boldly threw down the gauntlet, and maintained the theory of Huygens with the greatest ingenuity and talent. In his paper of 1800, entitled *Outlines of Experiments and Observations on Sound and Light*, he shows that light has a strong analogy with sound, and that it is produced by the undulation of a highly elastic ethereal medium which pervades all nature. In another paper, which he published in 1801, *On the Theory of Light and Colours*, he applies the theory of undulations to the explanation of natural phenomena; and lays down the following hypotheses:—1. That a luminiferous ether pervades the universe, rare and elastic in a high degree. 2. That undulations are excited in this ether whenever a body becomes luminous. 3. That the sensation of different colours depends on the different frequency of vibrations excited by light in the retina; and, 4th, That all material bodies are to be considered, with respect to the phenomena of light, as consisting of particles so remote from each other as to allow the ethereal medium to pervade them with perfect freedom, and either to retain it in a state of greater density and of equal elasticity, or to constitute, together with the medium, an aggregate which may be considered as denser but not more elastic. He then proceeds to demonstrate in nine propositions some of the leading truths in the theory, applying them in corollaries to the colour of striated surfaces, the colours of thin plates, the colours of thick plates, and the colours produced by inflection. In 1802 Dr Young published *An Account of some Causes of the Production of Colours not hitherto observed.* The cases described in this paper are the colours of delicate fibres and of mixed plates. The first he explains by the interference of two portions of light, one reflected from the fibre and the other bending round its opposite side, and at last coinciding nearly in direction with the former portion. The colours of mixed plates are those produced when moisture, butter, or tallow, are placed between two plates of glass, so that portions of air are intermixed with these substances. A candle seen through such a medium is surrounded with a sort of halo, and Dr Young considers the colours as produced by the light which passes through one of the media moving with greater velocity so as to anticipate the light which comes more slowly through the other. History.

In 1803 Dr Young published what may be considered as his principal paper, entitled *Experiments and Calculations relating to Physical Optics*, in which he has given an experimental demonstration of the general law of interference. By intercepting the rays which passed on one side of a body which formed fringes by reflection, the fringes disappeared, whether the interception was made on one side or the other of the body. This admirable experiment established the truth of his law of interference, and paved the way for those splendid generalizations respecting the undulatory theory which have so widely enlarged the boundaries of optics.

In April 1814, in a review of Malus', Biot's, and Brewster's *Experiments on Light*, which Young contributed to the *Quarterly Review*, he first published his explanation of the colours of crystallized plates exposed to polarized light by the law of interference, an explanation which is now universally admitted. In the article on *Chromatics*, which Dr Young contributed to this work, the reader will find a full account of the discoveries to which the law of interference has been so successfully applied. One of the most important applications of the undulatory theory was published in that article for the first time. Dr Young has there given an expression of the velocity of reflected light at a perpendicular incidence from bodies of various refractive powers, which is a simple function of the index of refraction.[1]

In giving an account of Sir William Herschel's discoveries, we have not mentioned his discovery of invisible heating rays beyond the red extremity of the spectrum, because we have ourselves succeeded in discovering that luminous rays exist at that part of the spectrum. In repeating Sir W. Herschel's experiments, M. Ritter of Jena placed muriate of silver in different parts of the spectrum, and found that it soon became black *beyond* the violet extremity, less black in the violet rays, becoming still less black in the blue and green, and so on till the blackness vanished. When he used muriate of silver, slightly blackened or disoxygenated, its white or original colour was partly retained by the red, and still more by the supposed invisible rays beyond it. In these experiments of Ritter's, as well as in those of Sir W. Herschel, the solar spectrum, when seen by the eye, as thrown upon paper, is extremely short. A great part of the violet extremity as well as the red extremity is invisible, so that when the thermometer and the muriate of silver seemed to be wholly out of the spectrum, they were completely within the violet and the red spaces, as we have placed beyond a doubt by comparing the length of a spectrum on paper with that which can be rendered visible by directly looking through a telescope at a highly magnified one.

Ritter, A.D. 1801.

Without knowing of the experiments of Ritter, Dr Wollaston discovered the chemical effects which exist at the violet end of the spectrum; but the merit of this experiment decidedly belongs to Scheele, who discovered that muriate of silver was more blackened in the violet rays than in any other part of the spectrum. The principal discovery in optics which we owe to Dr Wollaston, is his method of observing the spectrum, and his discovery of *five* fixed lines in it. The following is his own description of it:—"I cannot conclude these observations on dispersion without remarking that the colours into which a beam of white light is separable by refraction, appear to me to be neither seven, as they usually are seen in the rainbow, nor reducible by

Dr Wollaston, born 1766, died 1828.

[1] See Dr Peacock's *Life of Dr Thomas Young*, chaps. vi. and xii., Lond. 1855.

History. any means (that I can find) to three, as some persons have conceived; but that, by employing a very narrow pencil of light, four primary divisions of the prismatic spectrum may be seen with a degree of distinctness that, I believe, has not been described nor observed before.

"If a beam of day-light be admitted into a dark room by a crevice $\frac{1}{20}$th of an inch broad, and received by the eye at a distance of 10 or 12 feet, through a prism of flint glass *free from veins*, held near the eye, the beam is seen to be separated into the four following colours only, red, yellowish-green, blue, and violet; in the proportion represented in the figure.

"The line A that bounds the red side of the spectrum is somewhat confused, which seems in part owing to the want of power in the eye to converge red light. The line B, between red and green, in a certain position of the prism, is perfectly distinct; so also are D and E, the two limits of violet. But C, the limit of green and blue, is not so clearly marked as the red; and there are also, on each side of this limit, other distinct dark lines, *f* and *g*, either of which, in an imperfect experiment, might be mistaken for the boundary of these colours.

"The position of the prism in which the colours are most clearly divided is when the incident light makes about equal angles with two of its sides. I thus found that the spaces AB, BC, CD, DE, occupied by them, were nearly as the numbers 16, 23, 36, 25.

"Since the proportions of these colours to each other have been supposed by Dr Blair to vary according to the medium by which they are produced, I have compared with this appearance the coloured images caused by prismatic vessels, containing substances supposed by him to differ most in this respect, such as strong but colourless nitric acid, rectified oil of turpentine, very pale oil of sassafras, and Canada balsam also nearly colourless. With each of these I have found the same arrangement of the four colours, and, in similar positions of the prisms, as nearly as I could judge, the same proportions of them.[1]

"But, when the inclination of any prism is altered so as to increase the dispersion of the colours, the proportions of them to each other are thus also changed, so that the spaces AC and CE, instead of being as before 39 and 61, may be found altered as far as 42 and 58." These interesting observations are appended to his *Method of examining Refractive and Dispersive Powers by Prismatic Reflection*, which was published in the *Phil. Trans.* for 1802.

In the year 1800, Dr Wollaston published in the *Philosophical Transactions* some curious experiments and observations *On Double Images caused by Atmospherical Refraction*; and in the same work for 1802, he communicated a series of measures *On the Oblique Refraction of Iceland Crystal* in different planes, which he found, as the measures taken by Huygens had done before, to agree in a remarkable manner with the beautiful law established by the Dutch philosopher.

These researches of Dr Wollaston, but particularly the discoveries of Dr Young, had about this time drawn the attention of the philosophers of France to the subject of double refraction. Laplace had considered the deviation of the extraordinary ray as due to the action of the attractive and repulsive forces by which Newton and his successors had endeavoured to explain the ordinary refraction and reflection of light; and the French Academy of Sciences was thus led in 1808 to propose the double refraction of light as the subject of a prize to be adjudged in 1810. Among the few memoirs which were sent in competition for this prize, that of E. L. Malus, colonel of the imperial corps of engineers, was the successful one. After his return from the expedition to Egypt, he had composed his *Traité d'Optique*, a work of great merit; but as soon as the subject of double refraction was announced, he devoted himself to the inquiry with equal ardour and success. Residing in the Rue des Enfers, in Paris, he happened to view, through a doubly refracting prism, the windows of the palace of the Luxembourg, which were then reflecting to his eye the rays of the setting sun, and on happening to turn round the prism, he was surprised to perceive that one of the two images of each window vanished in every quadrant of the rotation of the prism. In pursuing this remarkable experiment, he was conducted to the splendid discovery which forms an epoch in the history of optics, *that when a pencil of light is reflected by a surface of glass at an angle of* 54° 35′, *or of water at an angle of* 52° 45′, *the reflected light possesses all the characters of one of the pencils formed by double refraction.* Hence the pencil was said to be *polarized* by reflection. When a pencil thus reflected was made to fall on another surface of the same kind at the same angle, but so that the plane of the second reflection was at right angles to the plane of the first, then not a single ray of the light suffered reflection, the whole pencil suffering refraction only. When the light fell upon a plate of glass, the light reflected from the second surface acquired the same property.

History. Discoveries of Malus.

On the 11th of March 1811, Malus announced to the Academy of Sciences, that when a pencil of light was thus polarized by reflection, the light which was at the same time transmitted through the surface consisted of a portion of light polarized in an opposite direction, and proportional to that which was reflected, and of another portion not modified, which preserves the properties of direct light. This last portion becomes less and less by transmitting the ray through a number of plates in succession till the transmitted pencil is wholly polarized in one direction.

Malus likewise made several experiments on the polarization of light by metals, and he was led to the conclusion that the difference between transparent and metallic bodies was, that the former refract all the light polarized in one direction, and reflect all that is polarized in the other, while metallic bodies reflect what they polarize in both directions.

In a series of experiments on crystals and organized substances, communicated to the Academy on the 19th August 1811, Malus found that they all *depolarized* a pencil of polarized light; that is, a pencil of polarized light which refused to be reflected by another surface properly placed, recovered its power of being reflected after being transmitted through certain crystals and organized substances. All crystals which did not crystallize in the form of the cube or the regular octahedron, were found to possess the property of depolarization; and the organized substances which he found to possess the same property, were the transparent and fibrous portions of leaves and flowers, the pellicles which cover the hazel, silken, and woollen fibres, white hairs, scales, horn, ivory, feathers, the skins of quadrupeds and fishes, shells, and the whiskers of a whale. Malus intended to prosecute this subject to a greater extent, but his brilliant career of discovery terminated by his death on the 7th February 1812.

Discoveries of M. Arago, born 1786, died 1853.

The loss of Malus, great as it was felt to be, was immediately supplied by his distinguished colleague in the Institute, M. Arago, who has added to this and other departments of science so many brilliant discoveries. On the 11th of August 1811, before the death of Malus, M. Arago communicated to the Institute a memoir "On a particular modification which the luminous rays experience in their passage through certain transparent bodies."[2] Upon exposing thin plates of sulphate of lime, mica, and rock-crys-

Malus, born 1775, died 1812.

[1] The observations in this paragraph are quite incorrect. Dr Blair's results, to which they stand opposed, have been placed beyond the reach of doubt.

[2] *Mémoires de l'Institut*, 1811, part i., pp. 93–134.

History. Discoveries of Arago.

tal, to polarized light, and subsequently analyzing the light which they transmitted by a prism of calcareous spar, M. Arago observed the most splendid complementary colours changing with every variation in the inclination of the plate. When the light was incident perpendicularly, and the plate turned round in its own plane, the colours were in all positions the same, though they varied in intensity. He found two positions, at right angles to each other, in which the crystal gave no colour; and these positions were those in which the principal section of the crystal was perpendicular to, or coincident with, the plane of primitive polarization. Setting out from these positions, the intensity of the ray gradually increased, and became a maximum at an angle of 45° to that plane. When the crystallized plate was fixed, and the analyzing plate turned round so as to vary the inclination of the plane of reflection from it, to that of the fixed plate which polarized the light primitively, the change in the colours was most beautiful. M. Arago observed that the colour reflected in any one position of the analyzing plate was *complementary* to the colour reflected in the perpendicular position. He also found that the power of depolarizing the different colours diminished with the thickness of the plate, and he reduced mica to such a degree of thinness that it depolarized no colours at all. In studying the same phenomena in sulphate of lime and rock crystal, M. Arago was led to the conclusion that the colours depended on some other cause than that of the thinness of the plate. M. Arago likewise discovered the depolarizing property in a piece of flint glass, about three quarters of an inch in thickness.

We owe also to M. Arago the discovery of circular polarization in quartz, which he made in 1811. By transmitting polarized light along the axis of the prism, he observed the tints to be different in their nature from the ordinary tints of the mineral, although they increased and diminished with the thickness of the plate. When analyzed with a prism of Iceland spar, he observed that the true images had complementary colours as in the ordinary tints, and that the colours changed, descending in Newton's scale as the prism was turned round, so that if the colour of the extraordinary image was *red*, it became in succession *orange-yellow*, *green*, and *violet*; and hence he drew the important inference that the differently coloured rays had been polarized in different planes in passing along the axis of the crystal. M. Arago's duties in the observatory prevented him from pursuing these valuable discoveries with that continuity of labour which they demanded.

A very important discovery was made by M. Arago respecting the colours of thin plates.[1] When the rings of thin plates in common light were examined through a rhomb of Iceland spar, M. Arago discovered that when the principal section of the rhomb was parallel and perpendicular to the plane of incidence, the intensity of the light in one of the images varied with the incidence, and that this image vanished altogether when the pencil of light was inclined 35° to the surface, or when it was incident at the maximum polarizing angle. This result was the same, whether he examined the reflected or the transmitted rings. Hence he inferred that the light of both the systems of rings was polarized in the plane of incidence, at the polarizing angle for glass. M. Arago has likewise shown that the colours of the reflected and transmitted rings are complementary, and that their intensities are exactly equal, completely neutralizing each other, or forming white light when they are superposed. The most interesting experiment, however, made by M. Arago, is that in which he examined the rings when a convex lens was pressed upon a metallic reflector. When viewed with a prism of Iceland spar, as before, one of the two images vanished at the maximum polarizing angle of the glass, but the phenomena were different above and below this angle. At less angles the dimensions and the colours of the rings were the same in both images, which differed only in the quantity of their light; but at greater angles the rings in the two images had their colours complementary, the one beginning from a white centre, and the other from a black one.

History. Discoveries of Arago.

We have already seen that Dr Young first applied the principle of interference to explain the colours of crystallized plates; but he did not explain why these colours are not produced excepting with polarized light. MM. Arago and Fresnel entered upon this inquiry, and obtained a satisfactory solution of the difficulty. They found that two rays of light polarized in the same plane produced fringes by their interference as in common light; that no interference at all takes place when these planes are at right angles to each other; and that at an intermediate inclination the interference is diminished, and the fringes decrease in intensity. In following out these interesting results, they found that two oppositely polarized pencils will not interfere even when their planes are made to coincide, unless they belong to a pencil which had been wholly polarized in one plane.

We owe also to M. Arago the beautiful discovery that the quantity of polarized light in the reflected and transmitted pencils of common plates are exactly equal.

We are indebted likewise to M. Arago for some important results respecting the interference of light. We have already seen that the interior fringes formed by diffraction disappear when the light which passes by one side of the inflecting body is stopped. M. Arago observed that these fringes were displaced by making the same light pass through a thin plate of some transparent substance, and that the bands were always shifted to the side on which the plate was placed. The amount of this displacement determines the velocity of light in the interposed medium, and consequently gives us a measure of the refractive power of that body with the highest degree of accuracy.

In conjunction with M. Biot, M. Arago published a valuable series of experiments on the density and refractive power of *nine* gaseous bodies measured in relation to atmospheric air taken as unity. Hydrogen stood at the head of the table, with a refractive index equal to 6·61436 (or 7·0335 if we use the density given by Berzelius), whilst oxygen stood at the foot of the table, with a refractive index of 0·8616.

The polarization of the light of the clouds and the blue sky had been noticed by Malus, Arago, and Sir David Brewster, but M. Arago was the first to study it with a polarimeter of his invention. He found that the polarization was intense towards the zenith, and increased to the distance of 90° from the sun, after which it diminished to the distance of 150°, where it became invisible when this last point was at some height above the horizon. That is, the point of the polarization to which he gives the name of the *Neutral point*, is situated 30° above the point opposite the sun.

By means of the polariscope, Arago found that the light of the moon and the tails of comets were slightly polarized. He found also that the light issuing obliquely from the sun's surface is not polarized; and therefore that the sun's light does not proceed from an incandescent mass,[2] but from a gaseous envelope of flame.

M. Biot, born 1774.

Among the most successful cultivators of physical optics, M. Biot holds a distinguished place. His attention was first directed to the colours of crystalline plates discovered

[1] *Mémoires d'Arcueil*, tom. iii., "Sur les Couleurs des Lames Minces."

[2] He had previously found that the light emanating obliquely from a red-hot metallic plate was polarized.

History. by M. Arago, and by nice instruments and indefatigable labour he determined the general laws of the phenomenon in reference to the thickness of the plates, and the composition of the tints as observed in sulphate of lime and rock-crystal, calcareous spar, and arragonite. He observed that at a perpendicular incidence the two colours correspond to those seen by reflection and transmission in thin plates of air, and he concluded that the thicknesses at which these colours were developed, were proportional to the thickness of the plate of air which gave the same tint in Newton's scale. These thicknesses were found to vary with the nature of the crystal, and were always much greater than the thicknesses of thin plates which gave the same tints. He had at first supposed that at oblique incidences the changes of colour followed the same law as in thin plates, but he afterwards found that the tint depended on the thickness of the crystal traversed by the refracted ray, and varied as the square of the sine of the angle which the direction of the ray formed with the optic axis. In these experiments M. Biot considered arragonite, sulphate of lime, topaz, and mica, as all having one axis of double refraction like calcareous spar.

Discoveries of Biot.

In order to explain these various phenomena, M. Biot communicated to the Institute in 1812[1] his ingenious but now exploded theory of *Moveable Polarization*. In this theory the particles of a polarized ray are supposed to preserve their primitive polarization till they reach a certain depth in the crystal, when a succession of isochronous oscillations round their centre of gravity take place, the axes of polarization being carried alternately to each side of the axis of the crystal. The depth through which the particle is carried during each of these oscillations, is assumed to be twice the depth through which it has passed before the oscillations began. When the ray emerges from the crystalline plate, the oscillations are supposed to stop, and the ray assumes a *fixed polarization* (in which the axes of the particles are arranged in two rectangular directions), as if the last oscillation had been completed when it quitted the plate.

The remarkable colours discovered by M. Arago along the axis of quartz, were carefully studied by M. Biot, and he and M. Seebeck, nearly about the same time, observed the existence of the very same colours in several essential oils and solutions, such as oil of turpentine, oil of laurel, oil of lemons, syrup of sugar, the two first turning the planes of polarization from right to left, and the two last from left to right. In a memoir laid before the Institute in 1818, M. Biot shows that the angular rotation of the plane of polarization is directly proportional to the thickness of the plate, and inversely to the square of the length of the fits as given by Newton. He then concludes that this property of turning the particles of light round their centres of gravity resides in the ultimate particles of solid or fluid bodies, that it is necessary to their very existence, and that it is entirely independent of their mutual distances and mode of aggregation.

M. Biot afterwards resumed this subject, and extended his researches to a great variety of substances; and he has still more recently employed circular polarization in detecting the constituents of particular vegetable substances where chemical analysis had partly or wholly failed. He has shown that the soluble portion of plants, or the farinaceous matter of grain and roots, to which he has given the name of *dextrine*, and which M. Raspail had considered to be of the nature of gum, turns the planes of polarization more powerfully to the *right* (hence the name *dextrine*) than the syrups of *cane sugar;* and that all the *gums*, and the syrups of the *sugar of grapes*, turn the planes of polarization to the left. M. Biot has also applied the same method of research in ascertaining the changes which take place in the sap of trees, and in analyzing the processes of vegetation which are concerned in the growth of wheat and rye. His researches are of great practical value in an agricultural point of view, and ought to impress on those whom it most concerns, the important truth, that the most recondite discoveries in science will sooner or later find a useful application.

History. Discoveries of Biot.

One of the most important discoveries made by M. Biot was the true nature of the double refraction and polarization in quartz, which Huygens had been unable to develop. M. Biot found that it differed from that of calcareous spar, in having the phenomena regulated by a *prolate* in place of an *oblate* spheroid, the least refracted image being the ordinary ray in quartz, and the extraordinary one in Iceland spar.

In 1840 M. Biot communicated to the Academy of Sciences an interesting memoir on *Lamellar Polarization*, which he considers as essentially different from molecular polarization; and by means of which he endeavours, but not at all successfully, to explain the remarkable phenomena discovered by Sir David Brewster in apophyllite, analcime, and other minerals. In the case of apophyllite, he conceives "that it has a positive molecular axis of double refraction coincident with the axis of the primitive prism, with two orders of lamellar systems, one perpendicular to the axis, and existing always with unequal degrees of intensity; and the other occasional, and composed of laminæ, which may be directed obliquely to this axis with all degrees of inclination, even till it becomes parallel to it."[2]

Sir David Brewster.

Whilst these researches were carrying on in France, Sir David Brewster was occupied with the same subject in Scotland. In his *Treatise on New Philosophical Instruments*, published in the beginning of 1813, he has shown that chromate of lead and realgar exceed the diamond[3] in refractive power; that diamond, phosphorus, and sulphur have their high refractive powers in the order of their inflammabilities; that fluor spar and cryolite have their refractive powers below all solid substances (excepting *tabasheer*), and lower dispersive powers than all other bodies; and that all doubly refracting crystals have a double dispersive power. He showed that oil of cassia had the least, and sulphuric acid the greatest action upon green light; that a tertiary spectrum is formed when prisms of the same substance but different angles are made to correct the dispersion by the inclination of one of them; and that achromatic combinations may be effected by prisms and lenses of the same kind of glass.

In the year 1812 he began to study the subject of the polarization of light, in consequence of having become acquainted with Malus' celebrated discovery of the polarization of light by reflection. He discovered the remarkable property of the agate, by which it gives only a single distinct image polarized in one plane; the property of depolarization possessed by almost all minerals, and by many animal and vegetable substances;[4] the polarized colours produced by thin plates of mica and topaz; the partial polarization of light by polished metals;[5] and the complete polarization of the exterior and interior rainbows.

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[1] *Sur un nouveau genre d'Oscillation que les Molecules de la Lumière eprouvent en traversant certains cristaux.*

[2] See *Mémoires de l'Institut*, tom. xviii., pp. 539–727; Abbé Moigno's *Repertoire d'Optique Moderne*, tom. i., p. 370; and Brewster's *Optics*, edit. 1853, pp. 279 and 346.

[3] In all tables of refractive powers of solids and fluids, *diamond* stood at the head, and *water* and *ice* at the bottom. Our author, however, placed various substances above *diamond*, and *tabasheer* far below *ice*.

[4] *Phil. Trans.* 1815, p. 27.

[5] These discoveries were communicated to the Royal Society of Edinburgh, and owing to the state of communication between France

History.

Discoveries of Brewster.

In the course of these inquiries our author discovered the two beautiful systems of elliptical coloured rings, which we see by transmitting polarized light along the two optical axes of topaz; and in consequence of his using a conical in place of a parallel beam of light in these experiments, he was led to observe the same system of rings, under different modifications, in various other bodies. While examining the depolarizing effect of a plate of mica at an oblique incidence, he was led to the discovery of the polarization of light by oblique transmission through bundles of crystallized or uncrystallized plates; and though Malus had anticipated him in this discovery, yet he had determined the law of the phenomena, which had escaped the notice of that skilful observer.

Hitherto no idea had been formed of the mechanical condition of bodies in which the polarizing and doubly refracting structure were exhibited; but in the years 1814 and 1815, a new light was thrown upon the subject by three discoveries made by Sir David Brewster, namely, that the polarizing structure could be produced in glass by heat, and also by rapid cooling;[1] that Prince Rupert's glass drops, formed by rapid cooling, possessed that structure;[2] and that *by means of simple pressure, that species of crystallization could be communicated to soft and indurated jellies, which forms two apparently polarized images, and exhibits the complementary colours by polarized light.*[3]

Law of polarization by reflection.

We have already seen that Malus considered the property of polarization by reflection as independent of the other modes of action which bodies exercise upon light. In order to investigate this subject, Sir David Brewster made an extensive series of experiments to determine the angles of maximum polarization by reflection, from the surfaces of bodies, and from the separating surfaces of different media. After encountering many difficulties, he was led to the discovery of the very simple law, *that the index of refraction is the tangent of the angle of polarization*, which is rigorously true for all separating surfaces, and for rays of all refrangibilities; and hence we obtain an immediate explanation of the perplexing fact, that at the maximum polarizing angle the polarization of the ray is never complete. When this law is expressed geometrically, it informs us that when a ray of light is polarized by reflection, the reflected ray forms a right angle with the refracted ray; that the sum of the angles of reflection and refraction is a right angle, or counting from the surface, that the angles of reflection and refraction are equal. In the same paper our author has shown that light may be completely polarized by two, three, or more reflections, at angles all above or all below, or partly above and partly below the angle of complete polarization; a greater number of reflections being required, as the incident ray approaches either to the refracting surface, or to a line perpendicular to it. In the same paper it is shown that every ray of light polarized by reflection has been acted upon by the refracting force, and that total reflection exercises an analogous action upon light with metallic surfaces.

Influence of heat.

The influence of heat in producing a transient polarizing structure in glass, led our author to an elaborate examination of the subject in 1815.[4] When the edge of a thick plate of glass is laid on a bar of hot iron, the heat gradually propagates itself along the plate, and its path is marked by the most beautiful fringes of polarized light; but no sooner has the heat entered the plate of glass than similar fringes appear on its upper edge, *where there is no heat at all.* After a certain period the whole surface of the glass is covered with coloured fringes, which are arranged in two similar polarizing structures at the edges, separated by two dark lines or axes from an opposite structure in the middle. When the glass is removed from the iron, the fringes gradually disappear, and are extinguished when the heat is uniformly diffused over the glass. If the plate of glass is made very hot in boiling oil, and is then allowed to cool with its edges against a plate of cold iron, it will exhibit in a fainter degree the fringes above described; but they are now all reversed, the middle structure having the same character as the external structures had formerly, and *vice versa.* If, when a plate of glass is covered over with the polarized tints, it is suddenly cut in two by a diamond in the direction of its length, the whole structure is instantly changed, and each piece has the same properties and structure as the whole, exactly like a portion detached from the end of a magnet. The same properties he found in muriate of soda, fluor spar, obsidian, semi-opal, horn, tortoise-shell, and various animal and vegetable bodies. The tints thus developed by heat exhibit, by their being made to cross one another and by other modifications, a series of the most brilliant phenomena within the whole range of optics.

History.

Discoveries of Brewster.

In continuing these experiments, our author found that when the plate of glass, after being brought to a red heat, was allowed to cool quickly, it exhibited permanently the same coloured fringes, a discovery which had likewise been made by Dr Seebeck of Nuremberg.

Influence of pressure.

This paper is followed by another, published in the same volume of the *Transactions*,[5] *on the communication of the structure of doubly refracting crystals to glass, muriate of soda, fluor spar, and other substances, by mechanical compression and dilatation;* and on the 17th November 1816, our author communicated to the Royal Society of Edinburgh another paper, *on the effects of compression and dilatation in altering the polarizing structure of doubly refracting crystals.*[6]

Optical properties of mother-of-pearl.

In 1816 he communicated to the Royal Society his experiments on mother-of-pearl, explaining the origin of its fine superficial colours, and showing that they could be communicated to wax, isinglass, the fusible metals, and even to lead, by hard pressure. In 1815 he published a paper *on the multiplication of images, and the colours which accompany them, in some specimens of calcareous spar,*[7] a subject which had exercised the sagacity of Huygens, Benjamin Martin, Brougham, Robison, and Malus. The last of these philosophers ascribed the multiplication of the images to the interception of the pencils by fissures within the crystal, and the colours to the thin plate of air which it inclosed; but Sir David Brewster discovered the true cause of the phenomena, and proved that there were no fissures nor plates of air; that the multiplication of the images arise from one or more veins of calcareous spar, which divided the rhomb into prisms, so as to form composite crystals, having the axes of crystallization and of double refraction of the two contiguous crystals turned round 180°, so that each of the two pencils formed by double refraction are subdivided in passing from one crystal to the other. He has shown also that the colours are the polarized tints produced by thin crystallized plates, these plates giving the regular system of coloured rings seen along the axis of calcareous spar, the light being polarized by the first prism of spar, and analyzed by the last. Hence it follows that the polarized tints of crystals were seen and studied by Huygens and his successors, without having any idea of what they were.

Colours in calcareous spar.

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and England, neither the author nor any of the members of the Society were acquainted with the previous discovery of M. Arago of the colours of crystalline plates, or with those of Malus on depolarization and metallic polarization.

[1] *Phil. Trans.* 1814, p. 1. [2] Ibid. [3] Ibid. 1815, p. 60.

[4] *Phil. Trans.* 1816, p. 46, and *Edinburgh Trans.*, vol. viii., p. 383, where the phenomena are represented by formulæ.

[5] *Edin. Trans.*, vol. viii., p. 156. [6] Ibid., vol. viii., p. 281. [7] *Phil. Trans.* 1815, p. 270, and *Edin. Trans.*, vol. viii., p. 165.

History.

Lenses of animals.

The crystalline lenses of animals had hitherto been supposed to increase regularly in density, from the circumference to the centre, for the purpose of correcting the spherical aberration. Sir David Brewster, however, showed in 1816,[1] that there were often *three* structures in such lenses,—a structure increasing in density from the centre, being accompanied with another diminishing in density, and that these structures displayed themselves in circular rings of polarized tints, traversed by a rectangular black cross, the tints themselves sometimes rising to a bright yellow of the first order. About the same time he discovered the remarkable property of the *diamond* of exhibiting irregular patches of doubly refracting structures, as if it had been in the state of gum, subject to irregular pressure or induration;[2] and having afterwards discovered gaseous cavities in the same gum, in which the expansive pressure of the included gas had communicated to the surrounding parts a regular doubly refracting structure, he corroborated his supposition that it had a vegetable origin,[3] which he has more recently confirmed by discovering that many diamonds consist of strata of different refractive powers, a property not possessed by any mineral body.[4]

Metallic polarization.

In the beginning of February 1815, when examining the action of metals upon polarized light, our author discovered that complementary colours were produced by one or more reflections from plates of gold, silver, and other metals; that analogous colours were produced by total reflection; that common light was wholly polarized in the plane of incidence by a number of metallic reflections, this number being greater in silver and gold than in the other metals. Though examined with much care both by our author and M. Biot,[5] the nature and law of these phenomena were still veiled in obscurity.

Biaxal crystals.

Hitherto all crystals were believed to have one axis of double refraction, like Iceland spar or quartz; but in the year 1817[6] Sir David Brewster discovered that the greater number of crystals, and among these arragonite, sulphate of iron, sulphate of barytes, sulphate of strontian, topaz, felspar, and nitre, had *two axes* of double refraction, which he called resultant axes, and which were more or less inclined to each other, as the intensity of the real axes more or less approached to equality. By measuring the deviation of the two pencils in different planes, he found that the double refraction was the same in every part of the same ring, disappearing along the resultant axis, and increasing with the value of the tints; and by projecting the coloured rings, and measuring the angular distances from the axis at which the same tints were produced, he was led to the true physical law of the tints, and of the deviation of the extraordinary ray. This general law, when applied to the polarized tints, is thus expressed: *The tint produced at any point of the sphere, by the joint action of two axes, is equal to the diagonal of a parallelogram whose sides represent the tints produced by each axis separately, and whose angle is double of the angle formed by two planes passing through that point of the sphere and the respective axes.* When the law is applied to the phenomena of double refraction, it may be thus expressed: *The increment of the square of the velocity of the extraordinary ray produced by the action of two axes of double refraction, is equal to the diagonal of a parallelogram whose sides are the increments of the square of the velocity produced by each axis separately, and calculated by the law of Huygens, and whose angle is double of the angle formed by two planes passing through the ray and the respective axes.* When the two rectangular axes are of equal intensity and of the same character, the preceding law gives the very same results as the law of Huygens does for one axis placed at right angles with the other two. When the crystal has three equal rectangular axes, their forces are in equilibrio in every part of the sphere, and there is neither double refraction nor polarization. When the first of these laws is applied to the mysterious actions of sulphate of lime, with the origin and classification of which M. Biot had been so much perplexed, and which he has represented by complicated and empirical formulæ, the whole mystery disappears, and *all* the diversified and capricious variations of tint which he had ascribed to secondary forces, become the legitimate and calculable results of two axes of double refraction.

History.

During these laborious researches, our author was led to the law by which the primitive forms of minerals are connected with the number of their axes of double refraction, and to point out the connection between the optical structure and chemical composition of crystals.

Absorption of light.

The absorption of common light, in virtue of which crystals exhibit different colours, or shades of colour, in different directions, had been long observed by Wollaston, Cordier, Bournon, De Drée, and others; but Sir David Brewster discovered that in a great number of coloured crystals, both with one and two axes of double refraction, polarized light was absorbed, according to regular laws depending on the inclination of the ray to the axis or axes of the crystal, and that in such crystals the two pencils are always differently coloured, the difference of colour disappearing in the direction of the axis, and rising to a maximum at right angles to it. These phenomena are finely seen in super-acetate of copper, dichroite, Brazilian topaz, and augite. These properties are shown by our author to be singularly modified by heat, and even communicated to crystals which do not naturally possess it. Absorbing crystals have been called *dichroitic,* and the property itself *dichroism.*

Circular polarization.

The subject of circular polarization was likewise examined by our author in quartz and amethyst.[7] He found that heat entirely removed from quartz the power of producing circular polarization, when the substance was reduced to fusion; he discovered it near the resultant axis of chrysoberyl, and in certain specimens of unannealed glass.[8] In examining the properties of the amethyst, he found that this interesting mineral combines the opposite structures of the two kinds of quartz, being composed of alternate strata of right and left-handed quartz, these two opposite actions destroying each other at their junction, where the colouring matter of the amethyst is principally apparent.

Amethyst.

Crystallized surfaces.

In all the experiments on the polarization of light by reflection from crystallized surfaces, their action was supposed to be the same as that of common solids and fluids; and Malus had distinctly stated it as the result of experiment, that Iceland spar had the same polarizing angle on all its surfaces and in every azimuth, its action being "independent of the position of the principal sections," "that its reflecting power extends beyond the limit of the polarizing forces of the crystal, and that as light is only polarized by penetrating the surface, the force which produces extraordinary refraction begins to act only at this limit."[9] Doubting the accuracy of these results, Sir David Brewster instituted a series of experiments *on the action of crystallized surfaces upon light,* by which he has established the remarkable fact that the angle of complete polarization varies from 57° 14′ to 59° 32′, on the surface of the rhomb of calcareous spar, being a minimum in the plane of the principal section, and a maximum in a plane perpendicular to it. But it is

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[1] *Phil. Trans.* 1816, p. 311. [2] *Edin. Trans.* 1816, vol. viii., p. 167. [3] *Geological Trans.* 1816.
[4] See our art. MICROSCOPE, vol. xiv., chap. i., sect. *Diamond Lenses;* and *Phil. Trans.* 1841, p. 41.
[5] *Traité de Physique,* tom. iv., p. 579. [6] *Phil. Trans.* 1818, p. 199. [7] *Edin. Trans.,* vol. ix., p. 139.
[8] "Treatise on Optics," *Lardner's Cabinet Cyclop.,* p. 128. [9] *Théorie de la Double Refraction,* p. 240.

History. Discoveries of Brewster

not merely the polarizing angle that is changed. When the ordinary reflecting force is weakened by causing the reflection to be made from the refracting surface of oil of cassia and Iceland spar, he found that the light was no longer polarized in the plane of reflection, and that the deviation from this plane depended on the inclination of the ray to the axis of the crystal, the deviation becoming less and less as the refractive power of the fluid was diminished. In the same paper he has shown that by altering the mechanical condition of the surfaces of crystals, and making the ray enter this surface from fluids of different refractive powers, the ordinary or the extraordinary image may be weakened or extinguished at pleasure.[1]

Apophyllite.

In the year 1816, Sir David Brewster discovered a remarkable system of coloured rings in apophyllite, a singularly constituted crystal, one part of which has one axis, whilst another part has two axes of double refraction. Different parts of this crystal possess different degrees of double refraction, with the same thickness, and at the same inclination to the axis; and the beautiful and symmetrical figure which a perfect crystal exhibits by polarized light, delineated in the most splendid colours, is perhaps the finest sight which the mineral kingdom can present to us.[2] By the aid of polarized light, our author discovered also a singular

Chabasie.

structure in certain crystals of chabasie, in which the double refraction gradually diminishes in successive strata, then vanishes, and re-appears with an opposite sign, the one double refraction being positive and the other negative; but the most remarkable of all these structures was that of

Analcime.

analcime, in which he discovered a new species of double refraction, in which the phenomena are related to *planes* instead of *axes*, in which the double refraction disappears.[3]

Grooved surfaces.

In the year 1829, our author communicated to the Royal Society of London five papers. The first of these, entitled *On periodical colours produced by the grooved surfaces of metallic and transparent bodies*,[4] contains an account of a new series of periodical colours exhibited by grooved surfaces, which succeed each other in a plane at right angles to that in which the usual spectra are seen, and producing a singular modification of these spectra. In the second

Double refraction by pressure.

paper, *on the double refraction produced by pressure in the molecules of bodies*,[5] he has shown that the axis of pressure is a regular axis of double refraction, and that the doubly refracting properties, which are not inherent in the molecules themselves, are produced by the pressure caused by the forces of aggregation, which generally differ in intensity in the direction of the three rectangular axes. The

Polarization by reflection and refraction.

other three papers treat of the laws of the polarization of light by reflection[6] and refraction,[7] and on the action of the second surfaces of transparent plates[8] upon light.

Elliptic polarization in metals.

We have already seen that Malus, Biot, and Sir David Brewster had been baffled in their attempts to unravel the complex phenomena of metallic polarization. The last of these authors had at various times resumed the investigation; but it was not till February 1830, that he communicated the result to the Royal Society, in a paper entitled *On the phenomena and laws of elliptic polarization, as exhibited in the action of metals upon light*.[9] All the phenomena of metallic polarization are shown to be those of elliptical polarization, connecting the phenomena of circularly polarized light with those of plane polarized light, the action of *silver* approaching nearest to that of totally reflecting surfaces by which circular polarization is produced, and that of *galæna* to transparent bodies or those not metallic by which plane polarization is produced. The colours accompanying these phenomena have no relation to those of crystallized plates, and in the case of silver and gold are extremely beautiful and splendid.

History. Discoveries of Brewster

New analysis of solar light.

Hitherto the analysis of solar light by Sir Isaac Newton had been regarded as complete, and incapable of any farther development. From this analysis he himself deduced the conclusion, *that to the same degree of refrangibility ever belonged the same colour*, and to the same colour ever belonged *the same degree of refrangibility*. So early as 1822, in a paper on the *monochromatic lamp*, &c.,[10] Sir David Brewster showed that some of the colours of the spectrum were *compound*, capable of being analyzed by absorbing media, and that *different colours had the same refrangibility*. This result stood in direct opposition to the Newtonian doctrine, and our author, in order to support it, undertook an elaborate series of experiments, the results of which were communicated to the Royal Society of Edinburgh in 1831 in a paper entitled *On a new analysis of solar light*, indicating *three primary colours forming coincident spectra of equal lengths*.[11] In these three overlapping spectra the intensity of each colour is a maximum at that point where the same colour is most intense in the compound spectrum. Hence it follows that all the colours in the solar spectrum are compound, consisting of red, yellow, and blue light in different proportions, so that if at any point we separate as many rays of each colour as is necessary to produce *white* light, by absorbing the excess at that point, we should exhibit the strange phenomenon of *white light incapable of being decomposed by the prism*. This has actually been done by Sir David Brewster, by means of absorbing media. This paper was followed, in 1833, by another, *on the colours of natural bodies*,[12] in which our author shows that they have not the same composition as those of thin plates, and demonstrates the truth of this opinion by a special analysis of the green colour of plants, the most prevalent tint in nature, and the one which Newton had pronounced to be of the third order. In the same year our author published his *Observations on the Lines of the Solar Spectrum, and on those produced by the earth's atmosphere, and by the action of nitrous acid gas*,[13] but we must reserve our notice of this paper till we come to describe the discoveries of Fraunhofer.

In the year 1837 our author pointed out a remarkable *connection between the phenomena of absorption and the colours of thin plates*,[14] and in 1838 described some new facts in the *colours of mixed plates*.[15] In 1841 he communicated to the Royal Society of London a series of new phenomena exhibited by *thin plates exposed to polarized light*;[16] and in 1843, to the Royal Society of Edinburgh, a paper *on the law of visible position in single and binocular vision*, in which he gave the true theory of the stereoscope, an instrument which was invented independently by Professor Wheatstone, and Professor Elliot of Edinburgh. In the year 1841 he communicated to the Philosophical Society of St Andrews an account of his observations *on the polarization of the atmosphere*, and of the *polarimeter* with which they were made;[17] and in 1845 he discovered the *neutral point* beneath the sun, which goes by his name.[18] In 1846 he communicated to the Philosophical Society of St Andrews, and also to the British Association of that year, an account of a new property of light—namely, its

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[1] *Phil. Trans.* 1819, p. 145. [2] *Edin. Phil. Jour.*, vol. i., p. 1; and *Edin. Trans.*, vol. ix., p. 317. [3] Ibid., vol. x., p. 187.
[4] *Phil. Trans.* 1829, p. 301; or *Edin. Jour. of Science*, vol. ii., p. 46. [5] Ibid. 1830, p. 87; or ibid., vol. iii., p. 28.
[6] Ibid. 1830, p. 69; or ibid. N.S., vol. iii., p. 160. [7] Ibid., p. 135; or ibid., p. 218. [8] Ibid., p. 145; or ibid., p. 230.
[9] Ibid., p. 287; or ibid., No. V., vol. iv., pp. 136, 247. [10] *Edin. Trans.*, vol. ix., p. 433.
[11] *Edin. Trans.*, vol. xii., p. 123; or *Edin. Jour. of Science*, N.S., vol. v., p. 197. [12] Ibid. [13] Ibid.
[14] *Phil. Trans.*, 1837, p. 245. [15] Ibid., 1838, p. 73. [16] Ibid., 1841, p. 43. [17] *Proceedings of the Society*, Dec. 5, 1841.
[18] Johnston's *Physical Atlas*, and *Trans. of Royal Irish Academy*, vol. xix., part ii.

History.

double reflection and *polarization*, as exhibited on the surfaces of *chrysammate of potash*, *chrysammate of magnesia*, and *murexide*.[1] In 1846, he published[2] his researches on the *decomposition and dispersion of light* in solid and fluid bodies (the *fluorescence* of Professor Stokes). In 1849 he exhibited to the Royal Scottish Society of Arts his *lenticular stereoscope*, now in universal use;[3] and in 1853 he discovered that the crystalline and doubly refracting structures could be communicated to crystalline powders by compression and traction.

Dr Seebeck, born 1770, died 1831.

Dr Thomas John Seebeck of Nuremberg was an active and successful cultivator of the science of optics. His first experiments on this subject were published in Schweigger's Journal for April 1813 and December 1814. In 1811 M. Arago observed the polarizing structure in thick pieces of flint, and in 1812 Sir David Brewster had noticed the same property in some pieces of plate glass.[4] In Dr Seebeck's paper of 1813, he observed the regular figure produced by polarized light, when the glass had the regular form of cubes and cylinders. In cubes of an inch in diameter, he found them to be indistinct, and not produced by fluor spar or rock-salt. In his second paper of December 1814, he shows that a plate of glass made red hot, and set upon its edges to cool, exhibits at the part which cools first a series of coloured fringes, which spread over the whole plate, the structure which produces them remaining permanently fixed in the glass. These experiments are posterior to those made in Scotland on the effects of heat upon glass, and on the polarizing structure of glass cooled in water.

Early in 1816, Dr Seebeck discovered the property of certain essential oils in producing the polarized tints, the property of single refraction possessed by tourmaline, and the system of coloured rings produced by Iceland spar; but in these discoveries he was anticipated, as we have seen, by others, though he is entitled to all the merit of a second discoverer.

In 1809 Dr Seebeck communicated to the Academy of Sciences at Berlin an interesting memoir *on the unequal production of heat in the prismatic spectrum*,[5] in which he showed that the place of maximum heat varied with the substance of which the prism was made, being in the *yellow rays* in the spectra formed by water (and according to Wunsch, in alcohol and oil of turpentine); in the *orange* in concentrated sulphuric acid, and solution of sal ammoniac and corrosive sublimate; in the *middle of the red* in crown and plate glass, and *beyond* the red in flint glass. Dr Turner[6] ascribed these results to the different powers of these media to refract the rays of solar heat; but Sir David Brewster explained them by supposing that colourless transparent bodies exercise the same variety of absorptive action upon heat that coloured bodies do upon light, the body in the last case becoming coloured in consequence of that action. Hence the maximum ordinate of heat will shift its position with the nature of the body, and we shall no doubt find media with several maxima and minima, and points of no heat at all, according as we increase the size of the prism or the thickness which the heat traverses.[7] The best way to carry on such researches is to use a prism of glass whose curve of heat is well ascertained, and then to determine the changes which take place in the curve by interposing thick plates of transparent solids and fluids.

This eminent philosopher would have done still more for the science of optics, had he not been attracted to the study of thermo-electricity, in the creation and extension of which he has immortalized his name.

Dr A. Seebeck.

We are indebted to Dr A. Seebeck for a series of instructive and accurate experiments on the polarizing angle of different substances, which confirm the accuracy of the law of the tangents,[8] and another on the polarizing angle of calcareous spar in different azimuths.

History.

We come now to that auspicious period in the history of optics, when this science was destined to receive the grandest accessions from the genius of M. A. Fresnel, engineer of roads and bridges. What Newton did for astronomy, Fresnel did for physical optics; and all Europe will, we are persuaded, confirm the decision which places him pre-eminently above all the other cultivators of this branch of science. The discoveries of Fresnel, however, are so connected with theoretical considerations, that it is impossible, in a historical sketch, to give anything like an idea of their magnitude and importance. The phenomena of rotatory polarization in quartz, which had so much perplexed philosophers, have been completely explained by Fresnel. He found that they arise from the interference of two circularly polarized pencils, propagated with different velocities along the axis of quartz, the one revolving from right to left, and the other from left to right, and that a plane polarized ray is equivalent to two circularly polarized rays of half the intensity. These facts he verified experimentally, by an achromatic combination of right and left-handed prisms of quartz, so disposed as to double the refraction of the images.

Fresnel, born 1788, died 1827.

Circular polarization.

M. Fresnel had also found that light was circularly polarized by two total reflections from glass at an angle of about 54° 37′; and by placing between two rhombs of glass, each of which polarized the light circularly and had their planes of reflection at right angles to each other, a crystallized plate, he observed that the light transmitted through this system exhibited phenomena analogous to those seen along the axis of rock-crystal. The rhomb of glass so cut, that when the incident rays enter and leave it perpendicularly, they have suffered two reflections at an angle of 54° 37′, is well known by the name of Fresnel's rhomb.

Theory of double refraction,

Fresnel's theory of double refraction and polarization, one of the finest efforts of genius, conducted its author to many important results which had escaped the notice of the most diligent observers. Hitherto it had been taken for granted by all, and appeared to be proved by Biot's experiments on topaz, that in biaxal crystals one of the rays followed the ordinary law of the sines; but it followed from Fresnel's theory that it did not, and by a series of the nicest and most difficult experiments he determined, that neither of the two rays have a constant velocity, both being performed according to a new law. What had been called the extraordinary ray, he found by his theory to be regulated by the law discovered by Sir David Brewster, and simplified in its mathematical expression by M. Biot, and he showed that all the phenomena of double refraction could be accurately calculated. The axes of elasticity in Fresnel's theory are the same as the axes of double refraction in Sir David Brewster's paper of 1818, and the laws of the composition and resolution of such axes in uniaxal, biaxal, and tessular crystals which have no double refraction, previously given by the latter, are all necessary results of the same theory.

and polarization.

But the most remarkable part of Fresnel's theory is his explanation of the polarization of light. The hypothesis of *transversal vibrations* first presented itself to Dr Young while considering the law of extraordinary refraction in biaxal crystals, as communicated to him by Sir David Brewster. M. Fresnel, however, showed that it was a necessary consequence of the laws of interference, and that the vibrations of a polarized ray are on the surface of the

[1] *Proceedings of Phil. Soc.*, St Andrews, Jan. 5, 1846; *Report of Brit. Assoc.*, 1846, p. 7; Prof. Stokes' paper on "Metallic Reflection," &c. in *Phil. Mag.* 1853.

[2] *Edin. Trans.* 1846, vol. xvi., p. 111.

[3] *Trans. Soc. of Arts*, 1849; *Phil. Mag.*, Jan. 1852; and *Treatise on the Stereoscope*, Lond. 1857.

[4] *Treat. on New Phil. Insts.*, p. 335.

[5] *Berlin Memoirs*, 1818-1819, p. 305, or *Edin. Jour. of Science*, vol. i., p. 358, No. 2, Oct. 1824.

[6] *Chemistry*, 3d ed., p. 84.

[7] *Second Report of the British Association*, 1832, p. 294.

[8] *Edin. Jour. of Science*, N.S., vol. v., p. 99.

History. wave, and perpendicular to the plane of polarization. In unpolarized light they are also only on the surface of the wave, and this species of light is conceived to "consist of a rapid succession of systems of waves polarized in every possible plane, passing through the normal to the front of the wave." Hence light is polarized by resolving the vibrations into two sets in two rectangular directions.[1]

Interference of polarized light. We have already slightly noticed the fine discoveries of MM. Arago and Fresnel on the interference of polarized light, and we can now only refer with admiration to the beautiful series of experiments by which the phenomena of moveable polarization were properly explained, and brought under the dominion of the undulatory theory. When a polarized ray proceeding from a luminous point is transmitted through two rhomboids of Iceland spar of equal thickness, whose principal sections are inclined 45° to the plane of primitive polarization, the emergent light will diverge as if from two near points, and the two portions will be oppositely polarized. MM. Arago and Fresnel found that the light formed by the union of these pencils was *plane*, *circularly*, or *elliptically* polarized, according to the difference of the paths traversed when they met. Following out this principle, MM. Arago and Fresnel were led to an *experimentum crucis*, to determine the accuracy of the theory of moveable polarization. A homogeneous ray of polarized light was transmitted through a plate of sulphate of lime, having its principal section inclined 45° to the plane of primitive polarization, and of such a thickness that it should be circularly polarized according to the undulatory theory, and plane polarized according to the other; and the result was decisive against the theory of moveable polarization.

Diffraction of light. We owe also to M. Fresnel the true theory of the inflection or diffraction of light. The Academy of Sciences made this the subject of their physical prize for 1818, and the memoir of our author was the successful one. He had at first adopted and extended the theory of Dr Young, that the fringes arise from the interference of the direct and inflected light; but he was afterwards obliged to admit, that rays passing at a sensible distance from the reflecting body, deviate from their primitive direction, and interfere with the direct light. This interesting effect he ascribes to a number of elementary waves sent from each portion of the surface of the principal wave when it reaches the reflecting body, and he determines the resultant of all the elementary waves sent by these portions to a given point. Upon applying this theory to various cases of inflection, he found it to agree so well with observation, that, with the exception of the cases of diffraction by narrow apertures, the theory did not err more than the 2500th part of an inch.

Reflection of light. Among the many important discoveries of Fresnel we must enumerate the theory of the reflection of light. Dr Young had shown on the undulatory theory, that at a perpendicular incidence the intensity of the reflected light was a very simple function of the index of refraction.[2] M. Poisson had arrived by another process at the same result, without knowing, we believe, what had been done by Dr Young;[3] and he afterwards extended his inquiries to different incidences.[4] The conclusions, however, at which this distinguished mathematician arrived, were inconsistent with observation; and Fresnel had the good fortune to give a complete solution of the problem, by combining the doctrine of transversal vibrations with the theory of waves. He assumes, that the elasticity of the ether in the two media are equal, but their density different, though he also solved the problem on the more general assumption, that the elasticity was different in the two media. He thus obtained formulæ for all incidences and all refractive powers, and the law of the tangents, as well as that of the equality of pencils polarized by reflection and transmission, became the consequences of these formulæ. At a perpendicular incidence the formula coincides with that of Young and Poisson, and at 90° the whole light is reflected, a result which has been verified by observation.[5] History.

Among the active cultivators of the science of optics we must place our distinguished countryman, Lord Brougham. So early as 1796, when he was only eighteen years of age, he communicated to the Royal Society of London an ingenious paper on the inflection of light, and in 1797 another on the same subject.[6] These researches were published before Dr Young discovered the key to this class of phenomena, and before Fresnel had explained them on the principle of the undulatory theory. In his early papers, Lord Brougham considered the phenomena of diffraction, as produced by *inflecting* and *deflecting* forces emanating from the deflecting body, and acting, as Newton also supposed, on the passing rays. In his recent investigations, communicated to the Academy of Sciences and to the Royal Society, however, he has used these terms solely for the purpose of rendering more distinct the account of his experiments; and he has avoided all reference to the two rival theories. Lord Brougham.

The recent investigations of Lord Brougham were made at Cannes, in Provence, with a very fine apparatus made for him by the late M. Soleil, and he repeated them in Paris before the Abbé Moigno and others in 1850, when they were communicated to the Academy of Sciences.[7] The originality and importance of the discoveries of Lord Brougham may be judged of from the two following propositions, which relate to a new property of the inflected and deflected rays:—

1. "The rays of light, when inflected by bodies near which they pass, are thrown into a condition or state which disposes them to be on one of their sides more easily deflected than before their first flection, and disposes them on the other side to be less easily deflected; and when deflected by bodies, they are thrown into a condition or state which disposes them on one side to be more easily inflected, and on the other side to be less easily inflected than they were before the first flection."

2. "The rays disposed on one side by the first flection are polarized (or are in a state resembling polarization) on that side by the second flection; and the rays polarized on the other side by the first flection, are depolarized and disposed on that side by the second flection."[8]

Contemporary with the discoveries of Fresnel were those of the late M. Fraunhofer of Munich, who made several important observations on the solar spectrum, on the diffraction of light, on refractive and dispersive powers, and on the refrangibility of the light of the fixed stars. By using fine prisms entirely free of veins, he discovered that the solar spectrum was crossed by about 590 black lines, and he executed a beautiful drawing of the spectrum, in which the most important of these are projected. Fraunhofer was not aware that Dr Wollaston had previously discovered *seven* of these lines; but this slight anticipation does not in the least degree diminish the singularity of this splendid discovery. He discovered similar lines in electric light, and in the spectra of the Moon, Venus, Mars, Castor, Pollux, Sirius, Capella, Betalgeus, and Procyon;[9] but none Fraunhofer, born 1787, died 1826.

[1] See *Bulletin de la Soc. Philomathique*, 1824, and *Mém. de l'Institut*, tom. xvii.
[2] See the article CHROMATICS, written by Dr Young, vol. vi., sec. xvi.
[3] *Mém. de l'Inst.*, tom. ii.
[4] *Mem. de l'Inst.*, tom. x.
[5] See *Ann. de Chim.*, 1821.
[6] *Phil. Trans.* 1796, p. 227, and 1797, p. 352.
[7] See *Comptes Rendus*, &c., 1850, tom. xxx., pp. 43, 67; and Abbé Moigno's *Repertoire d'Optique*, &c., tom. iv., p. 1498.
[8] Lord Brougham's paper is printed in the *Philosophical Transactions* for 1850, pp. 235–260.
[9] *Edin. Journal of Science*, No. xv., p. 7. Sir David Brewster asserts, that all the coloured stars derive their colours from defective lines in their spectra, having found these lines in those most strongly coloured.

History. whatever in artificial white flames. These lines he found to have a fixed position in relation to the coloured spaces, and, by measuring accurately the distance of prominent lines in the different coloured spaces, he obtained measures of the refractive and dispersive powers of bodies with a degree of accuracy hitherto unknown. Fraunhofer considered these lines as having their origin in the nature of the sun's light; but Sir David Brewster, who by particular methods has discovered more than twice the number of lines reckoned by Fraunhofer, has established the curious fact that many of them are produced also by the action of the earth's atmosphere. In his researches on this subject, Sir David Brewster discovered the remarkable property possessed by nitrous gas of producing analogous lines in great numbers, increasing in width with the thickness of the gas, or with an augmentation of its temperature. "The power of heat alone," says this author, "to render a gas, which is almost colourless, as red as blood, without decomposing it, is in itself a most singular result; and my surprise was greatly increased when I afterwards succeeded in rendering the same pale nitrous acid gas so absolutely black by heat, that not a ray of the brightest summer sun was capable of penetrating it."[1] Professors Miller and Daniel afterwards discovered numerous fixed lines, disposed at equal distances, in the vapour of bromine and iodine; and Sir David Brewster has more recently discovered hundreds of lines, under very singular circumstances, in the spectrum of an artificial substance, resembling mother-of-pearl;[2] but what is most interesting, these lines are *moveable, shifting their place in the spectrum by varying the incidence*, and are produced by the periodical action of *thin plates* inclosed in the substance. He has also discovered that broad dark bands like those produced by absorbing media, but entirely different from the nearly equidistant bands formed by single thin plates, are produced by a number of thin plates in a state of combination.[3]

Action of gases on spectrum.

Considering the lines of the spectrum as produced by interference, Fraunhofer was induced to make a complete series of experiments on the *inflection of light*, particularly on the splendid colours produced by gratings of wires, and grooved surfaces, which were published in the year 1822, in the *Memoirs of the Royal Bavarian Academy of Sciences*.[4] He afterwards repeated these experiments with a finer apparatus, and communicated an account of them to the Academy of Sciences at Munich, on the 14th June 1823.[5] The science of optics owes also to Fraunhofer the art of making the finest glass for achromatic telescopes and prisms; and such was the perfection at which he arrived, that, in a letter to the author of this article, he expressed his willingness to undertake an achromatic object glass *eighteen inches in diameter*. Our author wrote also a treatise on halos, parhelia, &c., in which he ascribes the small solar and lunar halos to the inflection of light by particles of vapour in the atmosphere, and the great halos of 45° to the refraction of hexagonal prisms of ice.[6]

Sir John Herschel.

Among the most distinguished contributors to optical discovery, Sir John Herschel occupies a high place. The deviations of the polarized tints from the colours of thin plates, or those of Newton's scale, had been discovered by Sir David Brewster in acetate of lead, tartrate of potash and soda, apophyllite, topaz, and various other minerals. He had divided these crystals into two classes, viz., those that had the *red* ends of the rings *inwards*, and the *blue* ends *outwards;* and those that had the *blue* ends of the rings *inwards*, and the *red* ends *outwards*.[7] In his paper of 1818, he states, that "in almost all crystals with two axes, the tints in the neighbourhood of the resultant axes, when the plate has a considerable thickness, lose their resemblance to those of Newton's scale, as will be more minutely described in another paper." Conceiving that these deviated tints arose from the superposition of systems of rings of different colours, Sir John Herschel examined the coloured rings by homogeneous light, and established the important fact that the inclination of the resultant axes varied in the different colours of the spectrum, the poles or centres of the rings approaching to each other in red, and receding in violet light, in some crystals; while in others they receded from each other in red, and approached in violet light. In tartrate of potash and soda, for example, the inclination of the axes was 75° 42′ in *red*, and only 55° 14′ in *violet* light.[8] These various axes all lie in the same plane, excepting in borax. In the paper containing this discovery, and in other two,[9] communicated to the Cambridge Philosophical Society, he has described various interesting phenomena which he discovered in different specimens of apophyllite and in hyposulphate of lime,[10] and which led him to some important conclusions respecting the law of proportional action of these crystals on the different colours of the spectrum.

History.

We have already seen that the force which produces circular polarization had been deemed a property of the ultimate particles of bodies, and totally unconnected with their mode of aggregation. In 1820 Sir John Herschel made the beautiful discovery, that the direction of the circular polarization in quartz was invariably the same with that of the plagiedral planes round the summit, the direction of the polarization being retrograde or direct, according as these planes leant forward or backward round this summit.

We owe also to Sir John Herschel an interesting inquiry into the *aberrations of compound lenses and object-glasses*,[11] a series of curious experiments on the phenomena produced by diaphragms or apertures of various shapes, variously applied to mirrors and object-glasses,[12] and a great number of original views and valuable experiments, which are contained in his *Treatise on Light*, one of the most valuable and original works on science which has appeared during the last century.

M. Mitscherlich.

M. Fresnel was, we believe, the first person who observed the change produced by heat on the tints of sulphate of lime. It is to M. Mitscherlich, however, that we owe the most complete investigation of this subject. He found that heat expands crystals differently in different directions. Iceland spar is expanded by it in the direction of its axis, while it is in a slight degree contracted in directions perpendicular to the axis. The rhomb thus approaches to the cube, and the double refraction is diminished. M. Mitscherlich also found that the inclination of the optical or resultant axes, which is about 60°, diminishes with heat till they actually form one axis, when by a farther increase of heat they again separate, and open out, as it were, in a plane at right angles to that of the laminæ. We have repeated this experiment, and enjoyed the remarkable sight of observing the one system of rings marching towards the other in the plane of the laminæ, and changing their form and size as they advanced.[13] An analogous, and even a more remarkable property, was discovered by Sir David Brewster in glauberite. At the freezing point glauberite has two optical axes for all the colours of the spectrum, the inclination of the axes being *greatest* in *red*, and *least* in *violet* light. When heat is applied, the two axes approach, and those of different colours unite successively, the crystal possessing

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[1] *Edin. Trans.*, vol. xii. [2] *Phil. Trans.*, 1837. [3] Ibid. [4] Ibid., vol. viii., 1822.
[5] *Edin. Jour. of Science*, No. xiii., pp. 101, 251. [6] See *Phil. Trans.* 1814, pp. 204, 205; and 1820, p. 95.
[7] *Edin. Jour. of Science*, No. xii., p. 348. [8] *Phil. Trans.* 1820, p. 45. [9] *Cambridge Trans.*, vols. i. and ii.
[10] Sir John discovered similar deviations in vesuvian or idocrase (*Treatise on Light*. art. 1125.) [11] *Phil. Trans.* 1821, p. 222.
[12] *Treatise on Light*, §§ 767, 768, &c. [13] *Lond. and Edin. Phil. Mag.*, 3d series, vol. i., p. 417.

History. the remarkable property of being a *uniaxal* one for *red*, and a *biaxal* one for *violet* light. By increasing the temperature, the optical axes open out in the same order, but in a plane at right angles to that in which they formerly lay, and long before the temperature has reached that of boiling water the planes of the axes in all the prismatic colours are perpendicular to their first position.[1] Such a crystal would form a delicate chromatic thermometer.[2] M. Marx has discovered an analogous property in topaz, in which the two axes separate with heat, the variation being greater in the coloured than in the colourless varieties.[3] Sir David Brewster has discovered that regular double refraction is produced in some soft substances by the application of heat.

M. Rudberg. Some very excellent and interesting results have been obtained by M. Rudberg, on the effect of heat upon doubly refracting crystals. He found that the extraordinary ray in calcareous spar (the line F was used) had its deviation increased 2′ 34″, as the refractive index increased 0·00043, by a rise of temperature equal to 64°, the refracting angle of the prism being 59° 55′ 9″; whereas the refractive power for the ordinary ray, either does not change at all, or decreases with the temperature by a quantity extremely small. In rock-crystal he found the deviation to be 42″, or 0·00027, both on the ordinary and extraordinary ray, the angle of the prism being 45° 20′ 5″. In arragonite he found that the double refraction decreased a little with the temperature.[4]

We owe also to M. Rudberg a series of valuable experiments on the refractive actions of the differently coloured rays in crystals with one and two axes of double refraction. His measures were taken in reference to the fixed lines in the spectrum, and the minerals he employed were rock-crystal, calcareous spar, arragonite, and colourless topaz. He confirmed the existence of two dispersive powers in doubly refracting crystals, announced long before by Sir David Brewster; and the variation of the inclination of the optic axes with the different colours of the spectrum, which had also been previously discovered by Sir John Herschel.[5] M. Rudberg was no doubt unacquainted with the previous labours of these authors, otherwise he would not have passed them over without notice.

M. Poisson, born 1781, died 1840. Like every other branch of physical science, optics owes much to the profound researches of M. Poisson, which are in general of too recondite a nature to find a place in a popular treatise. The theory of the colours of thin plates was left incomplete by Dr Young. The two interfering portions from the upper and under surface of the plate were obviously unequal, and therefore could not destroy one another wholly by interference, as they are found to do. M. Poisson remedied this defect by showing that there must be an infinite number of partial reflections within the plate, at each of which a very small portion of light was reflected, so that the sum of all these portions of light makes up for the defect of one of the pencils, and makes the interfering pencils equal. Hence M. Poisson has shown that at a perpendicular incidence, and at points where the effective thickness of the plate is an exact multiple of the length of half an undulation, the intensity of the reflected and transmitted light will be the same as if the plate were suppressed altogether, and the bounding media in absolute contact, so that when these media have the same reflective power, no light will be reflected and the whole transmitted. By the aid of the property discovered by M. Arago, that the light is reflected in the same proportion at the first and second surfaces of a plate, M. Fresnel extended M. Poisson's conclusions to all incidences.

In treating of the subject of diffraction, M. Poisson was led to the curious result that the centre of the shadow of a small opaque circular disc, exposed to light diverging from a single point, is as much illuminated by the diffracted light, as it would be by the direct light if the opaque disc were removed. By cementing a small metallic disc upon a plate of pure and homogeneous glass, M. Arago verified this remarkable deduction of theory. History.

In two memoirs read to the Academy of Sciences in 1828,[6] M. Ampère has made a valuable addition to the theory of Fresnel. By an indirect and not very rigorous process, M. Fresnel had been led to the equation of the wave surface;[7] but M. Ampère obtained a direct demonstration of it, deducing the equation in the manner which Fresnel had merely indicated, and he derived from this equation the elegant geometrical construction obtained indirectly by Fresnel. Ampère, born 1775.

M. Cauchy, born 1789, died 1857. The undulatory theory of light has been greatly advanced by the researches of M. Cauchy, a French mathematician of distinguished eminence. In determining the law of propagation of a plane wave, he shows that a disturbance originally limited to a given plane will give rise to three pairs of plane waves with uniform velocities, and parallel to the original plane, the two waves of each pair moving in opposite directions, but with equal velocities. He shows that the separate pairs will move with velocities represented by the reciprocals of the axes of an ellipsoid, the form of which is regulated by the position of the plane wave, and the nature of the system, the absolute displacement of the molecules being parallel to the direction of these axes. Hence a system of plane waves superposed at the point of original disturbance, will be divided into three corresponding systems, and these will generate by their superposition a curved surface of three sheets, each sheet being touched by all the plane waves of the system. If these principles are established, it will follow as a necessary consequence *that a single ray of light will be divided into three polarized rays*, one of which will in all cases have little intensity. M. Cauchy, as Dr Lloyd remarks,[8] has not pointed out the method of discovering this ray, or stated the precise physical condition on which its existence depends; but it "would seem to arise from the circumstance that the vibration normal to the wave is not absolutely insensible, so that the actual vibrations are not accurately in the plane of the wave."[9] "The results of M. Cauchy's general theory," continues Dr Lloyd, "embrace and confirm those of Fresnel; and the mathematical laws of the propagation of light are shown to be particular cases of the more general laws of the propagation of vibratory motion in any elastic medium composed of attracting and repelling molecules. Considered, however, simply with reference to the theory of light, the solution given by M. Cauchy cannot, I conceive, be considered as a complete *physical* solution. In other words, the phenomena of light are not connected *directly* with any given physical hypothesis, but are shown to be comprehended in the results of the general theory, in virtue of *certain assumed relations* among the constants which that theory involves. If, indeed, we were able to assign the precise physical meaning of these equations of condition, we should have nothing more to desire in the general theory of light; for these equations must necessarily express the characteristic properties of the vibrating medium. In this point of view, their discussion becomes a subject of the highest interest; and it is probably that the important conclusions, of which we have yet to speak, may in this manner be confirmed and extended." Triple refraction.

Before quitting this subject, however, we ought to men-

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[1] *Edin. Trans.*, vol. xi., p. 273; and *Lond. and Edin. Phil. Mag.*, 3d series, vol. i., p. 417.
[2] *Phil. Trans.* 1818, p. 108.
[3] *Jahrbuch der Chimie*, vol. ix.
[4] *Lond. and Edin. Phil. Mag.*, vol. i., p. 409.
[5] Ibid., vol. i., pp. 1, 89, 136, 146.
[6] *Ann. de Chimie*, tom. xxxix.; Moigno's *Repertoire d'Optique Moderne*, vol. i., pp. 84, 85.
[7] *British Assoc.*, 4th Report, p. 391.
[8] *British Assoc.*, 4th Report, pp. 391, 392.
[9] See p. 548 (note).

History. tion that there is an essential difference between the theories of Fresnel and Cauchy. In the former a ray is said to be polarized in or parallel to any plane, when the vibrations of the molecules of either are *perpendicular* to that line or plane; whereas, in Cauchy's theory, a ray is said to be polarized in or parallel to any plane, when the vibrations of the ether are performed in or parallel to that plane.

Dispersion of light. The inability of the undulatory theory to explain the dispersion of light was long one of the few exceptions to its universal application. Dr Young supposed that the material particles of bodies are incapable of permanent vibrations; that these vibrations will retard those of the ether; and that this retardation will be proportional to their frequency. Mr Challis, adopting Dr Young's idea, has endeavoured to explain the manner in which the undulations of ether within bodies are modified by their material atoms. He supposes that a sensible reflection takes places at every interruption of continuity in the medium; and he infers that the mean effect produced by a retarding cause proportional to the reflective power of the atoms, will be to make the condensation corresponding to a given velocity greater in a certain proportion than in free space, and to diminish the velocity of propagation in the same proportion. Mr Airy has more recently endeavoured to remove this difficulty, by supposing that in refracting media there may be something depending on time which alters their elasticity, in the same manner as in air the elasticity is greater with a quick than with a slow vibration of particles.

An anonymous writer, in an article which appeared in *The Philosophical Magazine*, has proposed another hypothesis for obtaining a difference of elasticity. He supposes that the ether accumulates itself round the particles of transparent media, and forms spheres of a density increasing towards their centre; and he infers that a succession of vibrations, communicated through a medium thus constituted, will give rise to new vibrations propagated with various velocities corresponding to those of the different rays in the spectrum.

The complete removal of this difficulty from the undulatory theory has been effected by the skill of M. Cauchy. Regarding the sphere of action of the ethereal molecules as indefinitely small, in comparison with the length of an undulation, it had been inferred that the velocity of the undulations must be constant in the same medium; but this restriction being removed as a groundless one, M. Cauchy considered the problem in a more general manner, and arrived at the result, that there exists a general relation between the length of the undulations and the velocity with which they are propagated, or the index of refraction; and consequently that rays of different colours will have different degrees of refrangibility. This relation is expressed by an equation involving two arbitrary constants, depending on the nature of the medium, and determinable by two values of the index of refraction for two waves of a known length. The refractive index for waves of other lengths may then be computed. Professor Powell has done this for several media,[1] whose refractive indices for the fixed lines in the spectrum have been determined by Fraunhofer, Rudberg, and himself; but though there is a general coincidence with the theory, the differences are in some cases rather inauspicious.[2]

Mr Airy. In examining the two rays produced by the double refraction of quartz, Mr Airy was led to a discovery which we consider as one of the most important in its results, and one of the most beautiful in its phenomena, that has yet been made in this branch of optics. The circular polarization of the two rays along the axis of quartz had been studied by different philosophers, and had been explained by Fresnel with singular ingenuity, on the principles of the undulatory theory. No attempt, however, had been made to account for the existence of this property only in the rays which pass near the axis of the crystal, or to define the limit where the circular polarization ended, and the plane polarization commenced. Fresnel, and all who have written on the subject, seem to have shrunk from this difficulty; but Mr Airy thought that the two kinds of polarization must have some connecting link, and by the aid of theory and experiment he succeeded in discovering it. In place of the two rays in quartz consisting of plane polarized light, as was universally believed, Mr Airy has shown that they both consist of elliptically-polarized light, the greater axis of the ellipse for the one ray being in the principal plane of the crystal, and the greater axis of the other perpendicular to that plane. One of the rays he found to be right-handed elliptically polarized, and the other left-handed elliptically polarized. The proportion of the axes of the ordinary ray is more nearly one of equality than the proportion of the axes of the extraordinary ray, each proportion being one of equality when the direction of the ray coincides with the axis, and becoming more unequal with the inclination, according to a law not yet discovered. The results calculated from the theory are in perfect accordance with those which Mr Airy has obtained from very nice and difficult experiments; so that we may regard this beautiful and singular property of the two rays of quartz as perfectly established. History.

Without knowing of the beautiful experiments of M. Arago, already referred to, Mr Airy was led to make the same experiment on the coloured rings formed between a lens and a metallic reflector, and to draw the same conclusion from it in favour of the undulatory theory. From a consideration of the formulæ of Fresnel, Mr Airy expected that if the rings were formed between two substances of different refractive powers, such as plate-glass and diamond, the light being polarized perpendicular to the plane of incidence, they should have a black centre at incidences less than the polarizing angle of the glass, and greater than the polarizing angle of the diamond; while they should have a white centre at all intermediate angles. These anticipations Mr Airy confirmed by experiment; and in the course of his observations he observed certain peculiarities in the phenomena, from which he has drawn the following conclusions, viz:—

1. When the angle of incidence is less than the maximum polarizing angle of the diamond, the nature of its reflection is similar to that of metallic reflection; the phase of vibration in the plane of reflection being more retarded than that of vibrations perpendicular to the plane of reflection, but perhaps by a smaller quantity than in reflection from metals.

2. In the neighbourhood of the polarizing angle, the nature of the reflection is different from any that has hitherto been described. The vibrations in the plane of reflection do not vanish, but on increasing the angle of incidence by three or four degrees, the phase of vibration is gradually retarded by about 180°. In the reflection of light whose vibrations are perpendicular to the plane of reflection, there is no striking difference between the effects of diamond and those of glass.

3. For angles of incidence greater than the polarizing angle there is no sensible difference between the effects of diamond and those of glass.[3]

Hitherto the mathematical theory of light owed almost all its development to the distinguished members of the Institute of France,—to Malus, Arago, Fresnel, Poisson, and

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[1] *Phil. Trans.* 1835–37.

[2] For a general account of the researches of M. Cauchy, particularly those on *metallic reflection*, see Prof. Forbes' Dissertation in this work, vol. i., pp. 920, 921; and also Abbé Moigno's *Repertoire*, &c., vols. i. ii. and iv.

[3] *Cambridge Trans.* 1832.

History. Cauchy; but it was now destined to receive a powerful impetus from those eminent members of Trinity College, Dublin, who have nobly sustained the honour of their country by their genius and discoveries. In his *Essay on the Theory of Systems of Rays*, Sir William R. Hamilton has given an elegant analytical form to that part of the theory of Fresnel which relates to the determination of the velocity and polarization of a plane wave; and he has deduced the velocity and direction of the ray from that of the wave, and consequently the form of the wave surface.[1] In these researches Sir W. R. Hamilton was conducted to the discovery of some new geometrical properties of the wave surface. He found that this surface has four conoidal cusps at the extremities of the resultant or optical axes, at each of which the wave is touched by an infinite number of tangent planes, forming a tangent cone of the second degree, while at the extremities of the lines of single-wave velocity there are four circles of plane contact, in every part of each of which the wave surface is touched by a single plane. These cusps and circles, the existence of which does not seem to have been suspected by Fresnel, have led Sir W. R. Hamilton to some remarkable theoretical conclusions respecting the laws of refraction in biaxal crystals. To this new property he has given the name of conical refraction, because a single ray is refracted into an infinite number, forming a kind of cone. This conical refraction is of two kinds, external and internal. In external conical refraction one internal cusp ray corresponds to an external cone of rays; and in internal conical refraction, an external ray incident at an angle corresponding to the line of single-wave velocity within, is connected with an internal cone of rays.[2]

Sir Wm. R. Hamilton.

Conical refraction.

Dr Lloyd. Sir W. R. Hamilton requested Dr Lloyd of Trinity College, Dublin, to inquire experimentally into the existence of these two kinds of conical refraction. For this purpose he selected arragonite, a crystal of great biaxal energy, and having its optic axes inclined about 20°. It was cut with parallel faces perpendicular to the line bisecting the two optic axes. Upon looking at the light of a distant lamp through the crystal, and in the direction of one of the optical axes, Professor Lloyd saw a point more luminous than the space immediately about it, and surrounded by something resembling a stellar radiation. Hence the direction of the optical axes may be determined by this modification of common light. When the adjustment was perfected, and the light transmitted in the exact direction of the cusp ray, there appeared at first a luminous circle, with a small dark space in the centre, and in this dark central space were two bright points, separated by a narrow and well-defined dark line. These appearances rapidly changed in shifting the minute aperture next the eye. On examining the emergent cone with a plate of tourmaline, Dr Lloyd was surprised to observe that only one radius of the circular section vanished in a given position of the tourmaline, and that the vanished ray ranged through 360°, while the tourmaline was turned through 180°. Hence it follows that all the rays of the cone are polarized in different planes. On a more attentive examination of this phenomenon, Dr Lloyd discovered the remarkable law, "That the angle between the planes of polarization of any two rays of the cone is half the angle between the plane containing the rays themselves and the axis." This law he found to be in perfect accordance with the theory.

The verification of the second kind of conical refraction Dr Lloyd found to be more difficult. The angle of the cone of rays which theory indicated should be seen within the crystal when a single external ray corresponding with a ray refracted along an optical axis, was 1° 55′ in arragonite. The external ray was divided into two, but when the critical incidence was gained, after much care in the adjustment, Dr Lloyd "at last saw the two rays spread into a continuous circle, whose diameter was apparently equal to their former interval.

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"This phenomenon was exceedingly striking. It looked like a small ring of gold viewed upon a dark ground; and the sudden and almost magical change of the appearance from two luminous points to a perfect luminous ring, contributed not a little to enhance the interest.

"The emergent light, in this experiment, being too faint to be reflected from a screen, I repeated the experiment with the sun's light, and received the emergent cylinder upon a small piece of silver paper. I could detect no sensible difference in the magnitude of the circular sections at different distances from the crystal.

"When the adjustment was perfect, the light of the entire annulus was white, and of equal intensity throughout. But when there was a very slight deviation from the exact position, two opposite quadrants of the circle appeared more faint than the other two, and the two pairs were of complementary colours. The light of the circle was polarized, according to the law which I had before observed in the other case of conical refraction. In this instance, however, the law was anticipated from theory by Professor Hamilton."

In addition to these interesting results, Dr Lloyd has published an account of a new case of interference, in which the experimental exhibition of the fact is much more manageable than in the experiment of two slightly inclined mirrors given by Fresnel. Dr Lloyd causes the light reflected at an angle of 90° from the surface of a single piece of plate-glass or a metallic reflector, to interfere with the direct light that passes parallel to the reflecting surface and near it. A screen placed on the other side of the mirror receives the direct and the reflected pencils, which, meeting under a small angle, after having traversed paths differing by a small amount, interfere. Dr Lloyd also received the two pencils upon an eye-piece placed at a short distance from the reflector, and saw a very beautiful system of bands, in every respect similar to one half of the system formed by the two mirrors in Fresnel's experiment.

Dr Lloyd has more recently, in 1836 and 1837, communicated to the Royal Irish Academy the results of his researches *on the propagation of light in uncrystallized media*. His object was to simplify and develop that part of M. Cauchy's theory which relates to the propagation of light in an ethereal medium of uniform density, and to extend the same theory to the case of the ether inclosed in uncrystallized substances, taking into account the action of the internal molecules. In the first part of his memoir Dr Lloyd has given good reason for concluding that the theory in its present form is insufficient to explain the phenomena of light in bodies, and that it becomes necessary to take into account the action of the material molecules. In doing this he limits himself to the comparatively simple case in which the molecules of the ether and the body are uniformly diffused. In the expression for the velocity of propagation each term consists of two parts,—one of which is due to the action of the ether, and the other to that of the body. "It is not improbable," says Dr Lloyd, "that there may be bodies for which the first or principal term is

[1] The *wave surface* is a geometrical surface employed to determine the direction and the velocity of reflected and refracted rays. It is spherical in a singly refracting medium; a double surface, or one of two sheets in a doubly refracting medium; and a surface of three sheets, on the supposition that there is a triple refraction. It has always a centre round which it is symmetrical; and the radii drawn from this centre in different directions represent the velocities of rays to which they are parallel. (Maccullagh's *Irish Trans.*, vol. xvii.)

[2] *Irish Trans.*, vol. xvii., p. 136. [3] *Phil. Trans.* 1030, p. 325; or *Edin. Jour. of Science*, N.S., No. viii., p. 259.

History. nearly nothing, the two parts of which it is composed being of opposite signs, and nearly equal. In this case the principal part of the expression for the velocity will be that derived from the second term; and, if that term be taken as an approximate value, it will follow that the refractive index of the substance must be in the sub-duplicate ratio of the length of the wave nearly. Now, it is remarkable that this law of dispersion, so unlike anything observed in transparent media, agrees pretty closely with the results obtained by Sir David Brewster in some of the metals. In all these bodies the refractive index (inferred from the angle of maximum polarization) *increases* with the length of the wave. Its value for the red, mean, and blue rays, in silver, are 3·866, 3·271, 2·824, the ratios of the second and third to the first being ·85 and ·73. According to the law above given, these ratios should be ·88 and ·79."[1]

We are indebted also to Dr Lloyd for an admirable *Elementary Treatise on the Wave Theory of Light*,[2] and an excellent history *Of the Progress and Present State of Physical Optics*, published in the Fourth Report of the meeting of the British Association held in Edinburgh,—a history not less characterized by its candour and truth, and absence of all national partiality, than by the profound and accurate knowledge of the subject which it everywhere displays. The only cultivator of physical optics to whom Dr Lloyd has done injustice is himself; and we are glad of the opportunity which we here enjoy of giving a brief and imperfect account of his original and valuable researches.

Professor Maccullagh, born 1809, died 1847.

It is with no less pleasure that we proceed to give an account of the optical discoveries of another Irish philosopher, who, at an early period of life, had placed himself in a distinguished position both as a mathematician and a natural philosopher. We have already seen that M. Ampère gave a direct demonstration of Fresnel's construction for finding the surface of the wave. His solution, however, was extremely difficult and complicated. The late Mr James Maccullagh was led in 1829 to believe, from the simplicity and elegance of the results, that there must be some simpler method of arriving at them, and, upon considering the subject with attention, he was led to a concise demonstration of the same theorem, and of some of the other leading points of Fresnel's theory. He has demonstrated a geometrical construction for finding the magnitude and direction of the elastic force arising from a displacement in any direction, and by his construction, with the aid of a few lemmas, he is immediately led to all the conclusions established by M. Fresnel. The magnitude and direction of this force are represented by means of an ellipsoid, having for its semi-axes the three principal indices of the medium, these axes coinciding in direction with, and being inversely proportional to, the axes of Fresnel's generating ellipsoid.

The properties of the wave surface, and its use in determining the directions and velocities of reflected and refracted rays, seem to have been discovered independently by Sir W. R. Hamilton, M. Cauchy, and Mr Maccullagh; and in a paper entitled *Geometrical Propositions applied to the Wave Theory of Light*, Mr Maccullagh has applied the properties of that surface to the geometrical development of the theory of double refraction.

Hitherto the remarkable laws of the double refraction of quartz, developed by the successive labours of Arago, Biot, Fresnel, and Airy, were merely a set of independent facts unconnected by any theory; but Mr Maccullagh, in a paper *On the Laws of the Double Refraction of Quartz*, sent to the Royal Irish Academy in February 1836, has shown how they may be explained hypothetically, by introducing differential coefficients of the third order into the equations of vibratory motion.

The theory of the action of the metals upon light having been long among the desiderata of physical optics, Mr Maccullagh thought it would be important to represent the phenomena of elliptic polarization, discovered by Sir David Brewster, by means of empirical formulæ, in a manner analogous to that employed by Fresnel in the case of total reflection. Mr Maccullagh has applied his formulæ to steel; and in computing from it the intensity of light reflected when common light is used, he obtained the remarkable result, that the intensity decreases very slowly up to a large angle of incidence (less that 75°), and then increases up to 90°, where there is total reflection. This result entirely accords with the remarkable fact discovered by Mr Potter,[3] that the intensity decreases with the angle of incidence as far as 70°. Mr Maccullagh conceives that experiment alone can decide whether the subsequent increase indicates a real phenomenon, or arises from an error in the empirical formulæ. History.

Mr Maccullagh deduces also from his formulæ the phenomenon observed by Mr Airy in the diamond; and he has applied it successfully to the phenomena discovered by M. Arago respecting the rings formed between a transparent and a metallic surface. In this experiment Mr Maccullagh and Dr Lloyd have both discovered a curious appearance unnoticed by any other author. Through the last twenty or thirty degrees of incidence, the first dark ring surrounding the central spot, which is comparatively bright, remains constantly of the same magnitude, though the other rings dilate greatly by an increase of incidence.

Hitherto the undulatory theory had been unable to give any explanation of the variation of the polarizing angle, when the light was reflected in different azimuths from calcareous spar, and other doubly-refracting surfaces. Mr Maccullagh, however, was induced to exercise his mathematical skill on this interesting subject; and so early as 1834 he communicated to Dr Lloyd an expression for the angle of polarization at the surface of crystallized media, when the plane of reflection coincides with the principal section of Fresnel's ellipsoid; and he found that the law, which he extended by analogy to all cases, represented with much exactness the observations of Sir David Brewster.[4] In a subsequent paper *On the Laws of Reflection from Crystallized Surfaces*,[5] he has explained the principles upon which his formula is founded. He was obliged to adopt the view of Cauchy, that the vibrations of polarized light are parallel to its plane of polarization, and being embarrassed by his third ray, he altered Cauchy's six equations of pressure, so as to make them afford only two rays, and give a law of refraction exactly the same as Fresnel's.

It appears, from a subsequent paper of Mr Maccullagh's,[6] that M. Seebeck[7] had solved the same problem long before,—namely, in the case where the plane of incidence coincides with the principal section of the crystal,—and had confirmed its accuracy by experiment. M. Seebeck had also pointed out a defect in Mr Maccullagh's formulæ Nos. 2 and 3, which induced the latter to resume the subject; and in a new paper, read to the Irish Academy on the 9th January 1837, a solution of the following problem is given for the first time:—"Supposing a ray of light, polarized in a given plane, to fall on a doubly-refracting crystal, it is required to find the plane of polarization of the reflected ray, and the proportion between the amplitudes of vibration in the incident, the reflected, and the two refracted rays." The hypotheses employed by our author are these, viz.,—

1. The density of the ether is the same in all media.
2. The vibrations are parallel to the plane of polarization.
3. The *vis viva* is preserved.

[1] *Irish Transactions*, vol. xvii. [2] Second edition, London, 1857. [3] *Edin. Jour. of Science*, N.S., No. 4.
[4] Professor Lloyd's "Report on Physical Optics," in the *Fourth Report of the British Association*, 1834, p. 374 (note).
[5] *Lond. and Edin. Phil. Mag.*, vol. viii., p. 103. [6] Ibid., vol. x., p. 42. [7] Poggendorff's *Annalen*, 1836, No. 6.

History. 4. The vibrations are preserved; that is, the resultant of the incident and reflected vibrations are the same as the resultant of the refracted vibrations. "This theory," says the author, "represents very accurately the experiments of Sir David Brewster and M. Seebeck on the light reflected in air from a surface of Iceland spar."

We owe also to Mr Maccullagh some interesting views respecting the nature of the light transmitted by the diamond and by gold-leaf. He conceives that there is a change of phase produced by refraction, as well as by reflection, from these bodies, the change being different according as the light is polarized in the plane of incidence, or perpendicular to it. If the incident ray, therefore, is polarized in any intermediate plane, the refracted ray should be elliptically polarized, which was found to be the case in gold-leaf. He conceived that the same remark explains the appearance of double refraction in specimens of the diamond which give only a single image, and that other precious stones are likely to have similar properties. Our author has obtained a general formula for the difference of phase between the two component portions of the refracted light,—one polarized in the plane of incidence, and the other perpendicular to it. He finds from this formula, that the difference of phase, which is nothing at a perpendicular incidence, increases until it becomes equal to the characteristic, at an incidence of 90°; and when the light emerges into air, the difference of phase is doubled.

The science of physical optics has been recently cultivated with great success by several distinguished members of the Academy of Sciences, and by other eminent individuals in Paris—by MM. Babinet, Senarmont, Jamin, Foucault, Fizeau, Becquerel, and Pasteur.

M. Babinet. The researches of M. Babinet are so numerous and varied that the narrow limits of this article will not permit us to give any detailed account of them. His memoirs on circular double refraction and polarization, on the rainbow and optical phenomena of the atmosphere, on the effect of heat upon the polarized rays in crystals, on dichroism and the absorption of polarized light by crystals, and his discovery of the neutral point, or the point without polarization, above the sun, to which his name is attached, place him on a high level among optical discoverers.[1]

M. Senarmont. The science of physical optics has received many important additions from the labours of M. Senarmont. In an interesting memoir published in the *Annales de Chimie*,[2] on the reflection of light, he has given new methods[3] of studying rectilineal and elliptical polarization, as exhibited in the reflection of light from transparent uncrystallized bodies, from uncrystallized bodies possessing metallic opacity, from transparent crystallized bodies, and from crystallized bodies possessing metallic opacity. He has also demonstrated that all the phenomena of reflection at the surfaces of bodies possessing metallic opacity are analogous to those at the surface of transparent crystallized bodies, and that they establish the existence of double refraction in crystals essentially opaque. In two interesting memoirs on the conductibility of crystallized bodies for heat,[4] he has shown that, in general, heat is conducted by bodies according to laws almost identical with those by which light is propagated.

The experiments of M. Senarmont "on the artificial production of dichroism or polychroism in crystallized substances," are exceedingly interesting. Having made a concentrated tincture of Campeachy wood, rendered purple by some drops of ammonia, he introduced it by absorption into crystals of nitrate of strontian, and upon transmitting a pencil of white light through a prism of the crystal, "*the phenomena were perfectly characteristic of polychroism in crystals with two optical axes, and absolutely similar to those observed by Sir David Brewster in cordierite* (tolite or dichroite), *and which M. Haidinger afterwards found in the andalousite of Brazil.*"[5] Other colouring matters introduced into other crystallized salts produced the same phenomena in different degrees. The colouring matter of amethyst, which Sir David Brewster found to exist between the two strata of opposite rotations, has obviously been deposited during the formation of the crystal in the same manner as the colouring matter in dichroitic minerals. The latest memoir of M. Senarmont with which we are acquainted is entitled *Researches on Double Refraction*,[6] in which he proposes to derive the laws of double refraction from a graphical representation of the iris or coloured band which exists at the confines of total reflection in uncrystallized bodies, but which becomes a circular coloured aperture with the two pencils formed in doubly-refracting crystals. In the same manner as the phenomenon of total reflection is a demonstrative proof of Snellius' law of the sines in simple refraction, so will the phenomena of total reflection, as exhibited by doubly-refracting pencils, be as conclusive a proof of the laws of double refraction.

Among the living cultivators of physical optics, M. Jamin of Paris has obtained a distinguished place. His discoveries are contained in four memoirs: on metallic reflection,[7] on the colours of metals,[8] on the reflection of light by transparent bodies, and on the double refraction and polarization of quartz. By means of the formulæ of Cauchy, M. Jamin has computed the colours of metals at angles of incidence near the perpendicular for *one* and for *ten* reflections, and he has found the theory in perfect accordance with experiment. Sir David Brewster had observed that bodies of high refractive power, such as diamond, realgar, and chromate of lead, do not polarize at any angle the whole of the incident light. This incomplete polarization M. Jamin discovered in nearly all transparent bodies. He found also that, with a few exceptions, they convert plane-polarized into elliptically-polarized light: these exceptions are *menilite* and *alum* cut perpendicularly to the axis of the octahedron.

M. Jamin.

Our limits will not permit us, in this part of our article, to give any account of the discoveries of M. Pasteur on circular polarization; of M. Becquerel on phosphorescence in relation to the different parts of the spectrum; of the fine experiment of MM. Foucault and Fizeau on the velocity of light in media of different densities; of the interesting researches and inventions of Plateau in reference to vision; of the analysis by Mosotti of the spectra produced by gratings; of M. Haidinger's observations on double reflection and pleochroism, and his method of determining by the eye alone the direction of the plane of polarization; and of the important discoveries of Professor Stokes respecting the nature of internal dispersion (to which he has given the name of *fluorescence*), and a supposed change in the refrangibility of light.

M. Pasteur. M. Becquerel. M. Foucault. M. Fizeau. M. Plateau. M. Mosotti. M. Haidinger. Stokes.

[1] See the *Comptes Rendus*, &c., tom. iv., and the Abbé Moigno's *Repertoire d'Optique Moderne*, toms. i. and iv. *passim*, for an account of M. Babinet's labours.

[2] Tom. xx., 3d series.

[3] In one of these methods M. Senarmont employs a double plate of quartz with opposite rotations. The Abbé Moigno regrets that he has not mentioned M. Soleil as "the inventor of this ingenious apparatus." The apparatus in a more perfect form—namely, as existing in a *single* plate of amethyst—was described by Sir David Brewster in the *Edin. Trans.* 1819, vol. ix., p. 150, long before it was proposed by M. Soleil.

[4] *Annales de Chimie*, &c., tom. xxi. xxii. xxiii., 1847–1851. An important memoir by M. Senarmont on the optical properties of doubly-refracting crystals will be found in the same journal, 3d series, tom. xxxiii., p. 391, and another on the optical properties of micas.

[5] *Comptes Rendus*, &c., 23d Jan. 1854, tom. xxxviii., p. 504.

[6] Ibid., 21st Jan. 1856, tom. xlii., p. 65.

[7] *Ann. de Chimie et Physique.*

[8] *Comptes Rendus*, &c., tom. xxv., p.714; ibid., tom. xxx., p. 99.

Introduction.

Although more intimately connected with the history of Photography,[1] we cannot omit to notice the new and remarkable property of light recently discovered by M. Niepce de St Victor, commandant of the Louvre, to whom the photographic art is under the deepest obligations. This new property or new action of light is finely exhibited in the following experiment:—"I expose," he says, "to the sun's light a sheet of card-board strongly impregnated with two or three applications of a solution of tartaric acid, or nitrate of uranium; after insulation, I cover with card-board the interior of a long and narrow tube of white iron, and after sealing the tube hermetically, I find that after *a very long lapse of time*, the card-board 'impressions' paper rendered sensible by the muriate of silver. The maximum effect is obtained in twenty-four hours, when the air is at its ordinary temperature; but if, after projecting into the tube some drops of water to moisten slightly the card-board, we again shut up the tube and expose it to a temperature of 40° or 50° (centigrade, we presume), and subsequently open its mouth, and place upon it a sheet of sensitive paper, we shall in a few minutes obtain a circular image of its mouth as strong as if the sensitive paper had been exposed to the sun." A simpler experiment, in which the same action is shown, is thus described by its author:—"Expose to the light of the sun, or even to diffused daylight, an engraving, and then place it above a sheet of sensitive paper prepared with muriate of silver. A copy of the engraving will be obtained in the same manner as if the paper and engraving had been exposed to the light of the sun."

M. Niepce de St Victor.

Introduction.

The intensity of the "persistent activity" thus exhibited by light after it has been imprisoned or laid up (*emmagasinée*) in paper or card-board, is more or less strong according to the nature of the substance, the time of exposure, and the state of the atmosphere. "A body rendered active" (that is, in which the light is actively persistent) "by insulation, will transmit this activity by contact in the dark to another body, such as tartaric acid."[1] If light is simply motion, it is difficult to understand how it can maintain its motion in the card-board till it gives itself out and impressions sensitive paper; or if its motion is extinct, how it can recover its state of motion from a state of rest. Whatever opinion we entertain of the theories of light, it seems quite clear that in its action on bodies there is a material agency different from that of simple motion. The ether itself may be a compound body consisting of, or containing, all the elements of matter.

OPTICS.

Having thus given a condensed sketch of the history of optical discovery from the earliest to the present times, we shall now proceed to the proper subject of this article. As the nature of this work requires that the subject be treated in a very popular manner, we shall pass briefly over those branches of Optics which are generally treated mathematically, and which occupy a prominent part in all ordinary treatises, and occupy our limited space with the more interesting departments of Chromatics, Physical Optics, the Double Refraction and Polarization of Light, the Explanation of Natural Phenomena, the Laws of Vision, and the Construction of Optical Instruments.

INTRODUCTION.

The ancients confounded the phenomena of vision with those of light, by supposing that when we see external objects something passes from the eye to the object. The phenomena of light, however, are totally independent of those of vision, and have a real existence in nature, whether we suppose them to be objects of vision or not.

Light.

1. Light is the element by means of which we see external bodies. These bodies may be divided, in reference to light, into two classes, *self-luminous* and *non-luminous*, or dark bodies. The first class includes the sun, the stars, flames of all kinds, and bodies which become luminous by friction, heat, and electrical and magnetical action. Such bodies become visible by the light which they themselves emit, and we then obtain a knowledge of their apparent form. The sun, for example, is seen to be round, and the flame of a candle to be of a conical shape. The second class of bodies, however, are never visible but when placed in the light of self-luminous bodies. It includes the moon and all the primary and secondary planets, of which we see only those portions upon which the sun's light directly falls, and all the other objects upon our own globe. When we bring a lighted candle into a room, its light falls upon all the objects in the apartment, and they become visible. These bodies reflect or throw back the light of the candle, and they scatter it in all directions, because they are, generally speaking, visible wherever we place our eye. But objects also become visible by the light thrown off by non-luminous bodies. When the moon has the form of a sharp crescent, we see the obscure part of her circular disc by the light thrown upon her from the earth, which is at that time almost fully illuminated by the sun. In like manner in the room lighted with a candle, objects are seen in corners and places upon which the light of the candle does not fall. These objects, however, are illuminated by the light of the candle thrown back by the white ceiling and walls of the apartment; and hence the reason why the ceilings of apartments should always be white, and why the walls should be as white as possible, if we wish to obtain the greatest quantity of light from a given flame.

2. The light thrown off from all bodies, whether self-luminous or non-luminous, if it has entered the body, is of the same colour as themselves. A red-hot body, or a stick of red sealing-wax, will make a sheet of white paper appear red if held near them. Light reflected from the surface of coloured bodies is white.

3. But though coloured bodies throw off light of the same colour with themselves, bodies do not appear of the same colour as that of the light which falls upon them. All bodies which are white in white light appear of the same colour as that of the light which falls upon them; but other bodies, such as red wax, appear red even in white light, a property which they derive from a peculiar structure acting upon the different colours of which white light is composed. Bodies of this kind, when illuminated with lights of different colours, always appear brightest in light of the same colour which they exhibit in white light. Thus a stick of yellow wax is more luminous than a stick of red wax, but the yellow wax will be less luminous than the red wax if we illuminate them both with red light.

4. Bodies, in their relation to light, are divided into two classes—*opaque* and *transparent*. An *opaque* body is one that stops the light that falls upon it, such as a piece of coal, or a plate of silver; and a *transparent* body is one which transmits the light through it, such as glass, water, and air. The most opaque body, however, may be made transparent by making it sufficiently thin, and the most transparent one may become opaque by making it sufficiently thick.

5. The opacity of bodies, or their power of intercepting light, gives rise to what is called the *shadows* of bodies. As the shadows of bodies are of the same form as the bodies, we thence deduce the fundamental optical fact, *that light moves in straight lines*. The same fact may be proved in a thousand ways, but most simply by placing three small

[1] See Professor Forbes' *Dissertation*, art. 569.

[2] See *Comptes Rendus*, &c., 1st March 1858, tom. xlvi., p. 448.

Introduction.

holes in a straight line. In this case the light will pass through them, but if any one of them deviates from the straight line, the light will be stopped. The same thing is finely seen, without any experiment, by admitting light into a dark room through a narrow circular aperture. Its path, marked out by the floating dust which it illuminates, will be seen to be a straight line.

6. Light issues or radiates in every direction and from every point in the surface of luminous and visible bodies. This fact is proved by the circumstance, that we see such bodies wherever we place our eye. However much we may magnify the bright part of the sun's disc through a telescope, or a sheet of white paper through a microscope, we shall never see any points destitute of light.

7. Light consists of separate and independent *parts*, which, when reduced to the smallest magnitude, are called *rays of light*. A beam of light transmitted into a dark room may be actually divided into smaller portions in a variety of ways. The smallest portion that we can allow to pass may be called a ray of light, and possesses the same properties as the larger beam.

8. *Light moves at the rate of* 192,000 *miles in a second.* This extraordinary property of light has been deduced by direct calculation from the immersions and emersions in eclipses of Jupiter's satellites, which become visible to us nearly a quarter of an hour earlier when the earth is nearest Jupiter than when it is farthest from that planet. The exact velocity of light obtained in this manner is 192,500 miles in a second; whereas Dr Brinkley and M. Struve have found it to be 191,515 miles in a second, from the phenomena of aberration; or 191,500, if we take 20″·36, which is the most recent measure of the constant of aberration.[1] This last determination is undoubtedly the most correct.

By a beautiful experiment, M. Fizeau has recently found that the velocity of the light of a lamp is 196,000 miles.

The velocity with which light travels is so inconceivable, that we require to make it intelligible by some illustrations.

It moves from the sun to the earth in $7\frac{1}{2}$ minutes, whereas a cannon-ball fired from the earth would require *seventeen years* to reach the sun.

Light moves through a space equal to the circumference of the earth, or about 25,000 miles in about the eighth part of a second. The swiftest bird would require *three weeks* to perform this journey.

Light would *demonstrably* require *five years* to move from the *nearest* fixed star to the earth, and *probably* many thousand years from the most remote star seen by the telescope. Hence if a remote visible star had been created at the time of the creation of man, it may not yet have become visible to our system.

9. When light falls upon any body, whether rough or smooth, coloured or uncoloured, a part of the incident light enters the body, and is either lost within it or transmitted through it; and part of it is reflected from its surface, either in the same or in a different direction from that in which it came. The light which enters the body and is lost, the light which is transmitted through the body, and the light which is reflected from it, suffer certain changes in its direction and in its physical properties. It belongs to the *geometrical* or mathematical part of optics to assign the laws which regulate the change of direction which light experiences when it is transmitted through, or reflected from bodies whose density is uniform, and whose surfaces have a geometrical form; and to *physical* optics, to explain the changes in the physical properties which light acquires in passing through bodies, in passing near them, or in being reflected from their surfaces.

Catoptrics.

The laws which regulate the reflection of light constitute that branch of optics which is called *Catoptrics*, and the laws which regulate the changes of deviation which light experiences when transmitted through bodies is called *Dioptrics*.

Part I.—CATOPTRICS, OR THE REFLECTION OF LIGHT.

Catoptrics.

The word *catoptrics* (derived from the Greek words κατα, *from*, and ὀπτομαι, *to see*) signifies that department of optics which treats of the reflection of light from the polished and regularly-formed surfaces of bodies, such as *water*, *glass*, and the *metals*.

The name of *speculum* or *mirror* has commonly been given to bodies that have regularly-formed and highly-polished surfaces. The word *speculum* is generally applied to polished metals, and *mirrors* to reflectors made of glass and covered with an amalgam of tin and mercury, or with a coating of pure silver, in order to increase their power of reflecting light.

There are four kinds of specula used in optics, namely, *plane*, *convex*, *concave*, and *cylindrical*, and when light falls upon any of these specula, which we shall always consider to be formed of polished metal, it is reflected according to the same law.

General Law of Reflection.

Let AD (fig. 2) be a ray of light which falls upon a *plane speculum* MN, and strikes it at the point D, this ray will be driven back in the direction DB, so inclined to the original ray AD, that if we raise from the point D a line DE perpendicular to MN, the angle BDE will be equal to the angle ADE. The ray AD is called the *incident* ray, DB the *reflected* ray, ADE the *angle of incidence*, and DBE the *angle of reflection*. The two rays AD, DB, and the perpendicular DE, all lie in the same plane AEBD. This plane is sometimes called the *plane of incidence*, and sometimes the *plane of reflection*, and it is always at right angles to the reflecting surface MN.

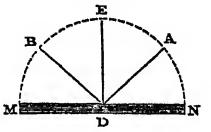

Fig. 2.

When the reflecting surface is *concave*, as MN in fig. 3, and is part of a sphere, whose centre is C, a ray of light AD, falling upon any point D, will be reflected in a direction DB, so as to form the same angle BDC, with a line CD drawn from the centre of the sphere to the point of incidence D, that the incident ray AD does, viz., the angle ADC. In this case the line DC is perpendicular to the reflecting surface at D.

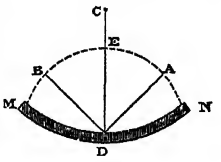

Fig. 3.

When the speculum is *convex*, as in fig. 4, and C the centre of its spherical surface, then if we draw CE, passing through any point D of the spherical surface MN, any ray of light AD, incident at D, will, after reflection, take a direction DB, having the same inclination BDE to DE that the incident ray AD has. In this case also the prolonged radius of curvature CE is perpendicular to the surface MN at D.

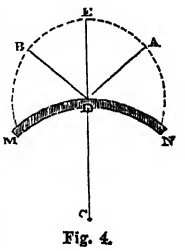

Fig. 4.

When the surface is cylindrical, the form of the reflecting line, or the line lying in the plane of reflection, is a circle in one direction, a straight line in another, and an ellipse

[1] See Aberration, vol. ii.

Catoptrics. in all intermediate ones; but in every case the reflected ray will take such a direction that the angle which it forms with a line perpendicular to a plane touching the cylinder at the point where the ray strikes it, will be equal to the angle which the incident ray forms with the same perpendicular. This is true of all curved surfaces whatever.

The results now stated have been established by direct experiment for all inclinations of the incident ray; so that it is a law universally true, that in the reflection of light *the angle of incidence is equal to the angle of reflection.* Hence it follows that when the incident ray is perpendicular to any surface, it is reflected back in the direction in which it came; and when the incident ray is parallel to the reflecting surface (when plane), or is inclined 90° to it, it will pass on without suffering any change in its direction.

By means of the law of reflection we can easily determine, even without any calculation, the effects produced upon light by specula and mirrors, and the shape, and magnitude, and position of the images of all objects seen by reflection from them. These effects we shall now proceed to consider in their order.

Definitions.—*Parallel rays* are those which are parallel or equidistant, as AD, A′D′ (fig. 5).

Diverging rays are those which issue or diverge from a point, and separate from each other, forming an angle, as AD, AD′, AD″ (fig. 6).

Converging rays are those which *converge* to a point, or approach to one another, as AD, A′D′, A″D″ (fig. 7).

Sect. I.—On the Reflection of Rays from Plane, Concave, and Convex Mirrors.

Reflection from Plane Mirrors.

Reflection of Parallel Rays.—When parallel rays AD, A′D′ fall upon a plain speculum MN at the points D, D′, they will preserve their parallelism after reflection. Drawing the perpendiculars DE, D′E′, make the angles of reflection EDB, E′D′B′ equal to the angles of incidence ADE, A′D′E′, and it will be found that DB is parallel to D′B′. If the space between AD, A′D′ be supposed to be filled up with other rays parallel to AD, the space between DB and D′B′ will also be filled up with parallel rays. Hence a beam of parallel rays ADD′A′ will be reflected into the parallel beam BDD′B′, the latter being the same as the former, but inverted. If the inverted beam suffers another reflection from another mirror, parallel to MN, it will be restored to a position exactly parallel to ADD′A′, and no longer inverted.

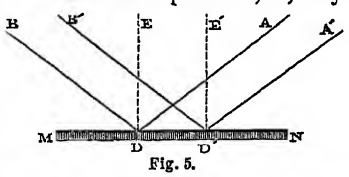

Fig. 5.

Reflection of Diverging Rays.—When diverging rays, AD, AD′, AD″, fall upon a speculum MN, they will be reflected in directions DB, D′B′, D″B″, found by making the angles BDE, B′D′E′, B″D″E″ respectively equal to ADE, AD′E′, AD″E″; and the reflected rays being continued back till they meet, they will be found to meet at a point A′, so that the line AA′ is at right angles to MN, and AN equal to A′N. Hence the rays will have the same divergency after reflection as before it, and as if they came from A′, the reflected beam being inverted, as in the preceding case.

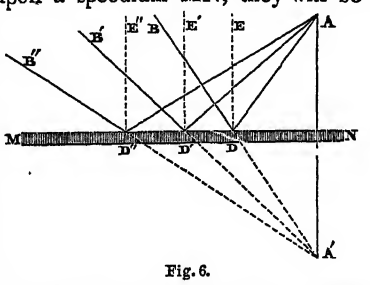

Fig. 6.

Reflection of Converging Rays.—When converging rays, AD, A′D′, A″D″, fall upon a speculum MN, they will converge after reflection to a point B′, so situated that if BB′ is at right angles to MN, B′M will be equal to BM. The reflected rays, DB′, D′B′, D″B′, will be found by making the angles EDB′, E′D′B′, E″D″B′, respectively equal to the angles of incidence, ADE, A′D′E′, A″D″E″.

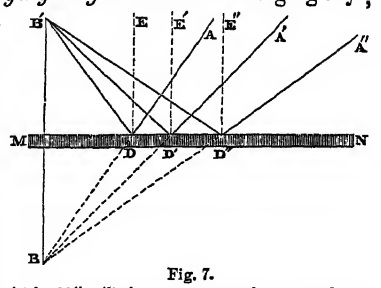

Fig. 7.

Reflection from Concave Mirrors.

Reflection of Parallel Rays.—Let MN (fig. 8) be a *concave* mirror whose centre of concavity is C, and let parallel rays, AD, A′D′, A″D″, fall upon the mirror, the central ray AD passing through the centre C. From C draw the lines CD′, CD″. Then since CD′ is perpendicular to the mirror at D′, the ray A′D′ will be reflected in the direction D′F, so that the angle of reflection CD′F is equal to the angle of incidence CD′A. In like manner, the ray A″D″ will be reflected to F, and the central ray AD will be reflected back to F also; all intermediate rays being likewise reflected to F.

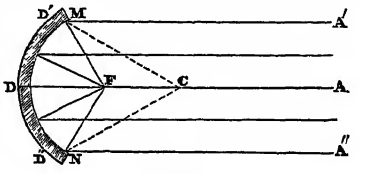

Fig. 8.

If the curvature of MN is not deep, and if the points D′, D″ are taken near D, it will be found by making the angles of reflection equal to the angles of incidence, that the rays all meet accurately at F, which is called the *focus* of the mirror for parallel rays, or its *principal focus.* This *focus* is in all mirrors exactly half-way between the centre C and the surface of the mirror.

The point F derives its name of *focus* from its being the burning point of a mirror, or the point where the parallel rays issuing from the sun are most condensed, and therefore occasion the most powerful heat.

Reflection of Diverging Rays.—Let AD, AD′, AD″ (fig. 9) be diverging rays issuing from A and falling upon the mirror MN, whose centre is C, and principal focus O. Then if we make the angles of reflection equal to the angles of incidence, as in the last case, we shall find that the rays will be reflected to a point F, between the centre C of the mirror, and its principal focus O. If the radiant point A is removed from the mirror, and the rays fall on the same points of it, it is manifest that the incident rays will be removed farther from the perpendiculars CD′, CD″; and consequently the reflected rays which meet at F will also be removed farther from them. Hence F will approach to O; and when A is infinitely distant, and the rays parallel, F will coincide with O. But if A approaches to the mirror, the incident rays will approach to the perpendiculars; and as the reflected rays will do the same, their point of concourse F will approach to C. When A reaches C, the focus F will also reach C, and the reflected ray will coincide with the incident ray.

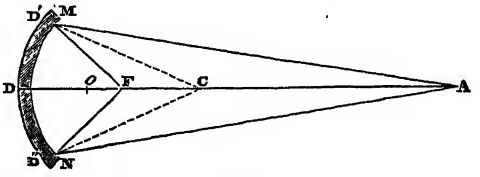

Fig. 9.

Catoptrics. If A still advances towards the mirror, the incident rays will get within the perpendicular, and therefore the reflected rays will be without it, and their point of concourse F will advance from C outwards, in proportion as the radiant point advances from C inwards. When A reaches the principal focus O, the reflected rays will be parallel, as seen in fig. 8; and when A comes still nearer the mirror, the reflected rays will diverge, as if they proceeded from some point behind the mirror, this point being called the *virtual* or imaginary *focus* of such rays.

In all the preceding cases the point A, from which the rays issue, and the point F, where they are collected by reflection, are called *conjugate foci*, because if we make A the radiant point, F will be the focus; if we make F the radiant point, A will be the focus.

The conjugate foci of a concave mirror may be easily found by projection. The following rule will give the focus more accurately when the rays A′D′, A″D″ are not far from the central one AD. Multiply the distance of the radiant point from the mirror, or AD, by the radius CD, and divide this product by the difference between double the distance AD and the radius CD, and the quotient will be the conjugate focal distance required, or FD. If twice AD is less than CD, the conjugate focal point will not be before the mirror, but behind it, the focus being in that case a virtual one.

Reflection of Converging Rays.—Let AD, A′D′, A″D″ (fig. 10) be rays converging to a point *a* behind the mirror

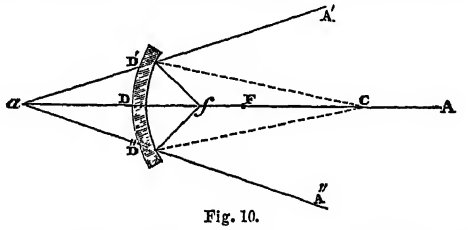

Fig. 10.

MN, whose centre is C. Having drawn CD′ and CD″, make the angles of reflection CD′*f*, CD″*f* respectively equal to the angles of incidence A′D′C, A″D″C; and D′*f*, D″*f* will be the reflected rays having their focus at *f*, between the mirror and its principal focus F. If the point of convergence *a* of the rays, or the conjugate focus, approaches to the mirror, the other conjugate focus *f* will also approach to it; and if it recedes from the mirror, the focus *f* will also recede, reaching F when *a* is infinitely distant, in which case A′D′, A″D″ are parallel, as in fig. 8. The following is the rule for finding the conjugate foci when one of them is given:—

Multiply the distance of the point of convergence from the mirror, or *a*D, by the radius of the mirror, or CD, and divide this product by the sum of double the distance *a*D and the radius CD, and the quotient will be the conjugate focal distance required—namely, *f*D—the focus *f* being in front of the mirror.

Reflection from Convex Mirrors.

Reflection of Parallel Rays.—Let parallel rays AD, A′D′, A″D″ (fig. 11) be incident upon the convex mirror MN, whose centre is C. Draw the perpendiculars CE, CE′ passing through D′ and D″, and making the angles of reflection ED′B, E′D″B′ equal to the angles of incidence A′D′E, A″D″E′; the reflected rays will be D′B, D″B′, whose virtual focus F is behind the mirror, and so situated that FD is equal to FC.

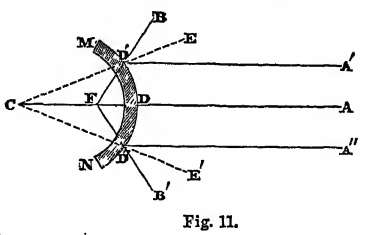

Fig. 11.

Reflection of Diverging Rays.—If we suppose the rays AA′A″ to diverge from any point in the line or axis AD, they will recede from CE, CE′; consequently the reflected rays D′B′, D″B′ will recede also; that is, will become more divergent, as if they came from a focus between F and D, the virtual focus approaching to D as the radiant point A approaches to D. Catoptrics.

Reflection of Converging Rays.—In like manner, if the rays AA′A″ widen at A—that is, converge to some point behind the mirror MN—they will approach to CE and CE′, so that the reflected rays D′B, D″B″ will also approach to CE, CE′, and consequently diverge less, or have their virtual focus between F and C. When the converging rays coincide with CE, CE′, they will be reflected back in the direction in which they came, having C for their virtual focus. When the converging rays pass CE, CE′, the reflected rays will also pass to the opposite side, and converge less after reflection, having their virtual focus beyond C. When they converge to F, the reflected rays will be parallel, as in fig. 11, where we may suppose BD′, B′D″ the incident, and D′A′, D″A″ the reflected rays. When the rays converge to a point between F and D, the reflected rays will converge to a point in the axis; and as the point of convergency of the incident rays approaches to F on the one side, the point of convergency of the reflected rays will approach to it on the other.

It would have been easy, by the simplest elements of geometry, to have demonstrated the preceding truths; but the demonstration would have been rigorous only when the rays fell upon the mirror at points infinitely near D in the axis AD. By finding from projection the foci of rays of all kinds, and falling upon the mirror at all degrees of obliquity, the reader will acquire more substantial knowledge of the subject than he can do either from geometrical or algebraic demonstrations. The same observation is applicable to the results obtained in the following section.

Sect. II.—On the Formation of Images by Apertures, and by Plane, Concave, Convex, and Cylindrical Mirrors.

Formation of Images by Apertures.—In optics an image is a luminous resemblance or picture of any object whatever, formed either on a white ground, such as a sheet of paper, or seen through ground glass, or suspended in the air.

In order to understand how images are formed, let us suppose that a soldier is standing on the outside of an open window (fig. 12), with a *red coat* and *blue trousers*, strongly

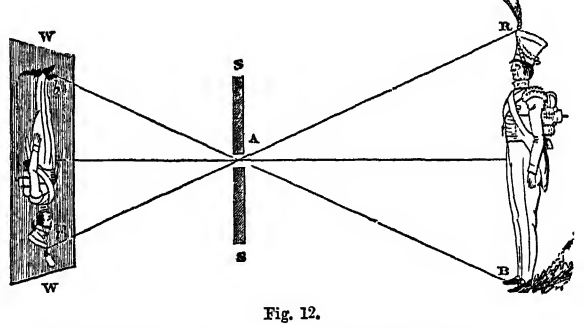

Fig. 12.

illuminated by the sun. The white wall WW opposite the window is illuminated by all the light which enters the window, the blue light of the sky, the green foliage, the red coat, and the blue trowsers, so that it has no distinct colour, but a mixture of all these. If we close the shutters SS, so as to allow no light to fall upon the wall but the red light of the coat and the blue light of the trowsers, it will be illuminated only by a mixture of red and blue light. But if we close the shutters completely, and leave only a small hole A, about

Catoptrics. half an inch in diameter, then it is obvious that the *red* rays at and below R, passing through the hole A, will illuminate the opposite wall at and above *r* with *red* light, and the *blue* rays the opposite point at and below *b* with *blue* light; and that no *red* light can fall upon *b*, and no *blue* light upon *r*. Hence we shall have the *red* body of the soldier rudely shadowed out at and above *r*, and his *blue* legs at and below *b*, this small image being inverted, because the rays from the upper part of his body fall upon the lower part of the wall, and the rays from the lower part of his body upon the upper part of the wall. If we make the hole A smaller and smaller, the inverted image of the soldier will become more and more distinct, the colours will be better separated, and the picture may be made so distinct, that the features of the individual could be recognised. Now this separation of the various lights that at first fell upon the wall is effected solely by diminishing the aperture through which they pass; for if the aperture is exceedingly small, then as two rays cannot proceed from the same point of the object, they cannot fall upon or illuminate the same point of the image, and hence each point of the object is represented on the wall by the colour of the light which it throws out.

As the coloured rays from the soldier are thrown off in all directions, an inverted image of that soldier may be formed in any part of space, by excluding all the other rays except those which pass through a small aperture. It is manifest, from a simple inspection of fig. 12, that the size of the inverted image will diminish not only with the distance of the aperture from the soldier, but also with the distance of the wall WW from the aperture.

Formation of Images by Concave Mirrors.—The effect of a concave mirror in forming an image is the same as that of an aperture, but it produces a finer effect, and acts upon a different principle.

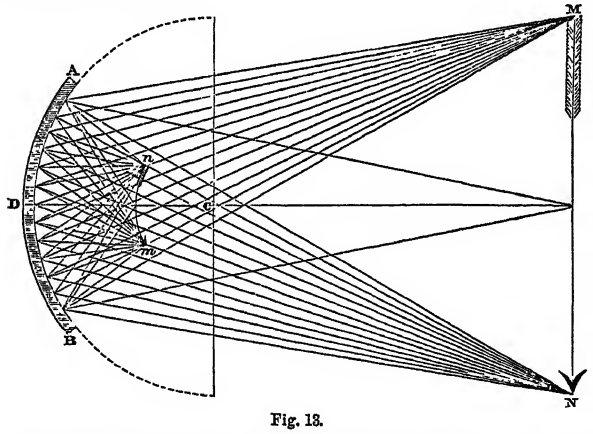

Fig. 13.

Let AB (fig. 13) be a concave mirror, C its centre, and MN an object placed before it. Of all the rays which flow from every part of this object in every direction, we shall consider only those which issue from its extremities M,N. The rays from M radiate in every direction, but those which fall upon the mirror, namely, the pencil or cone MAB, are the only ones which require our notice. This pencil of diverging rays will have its focus at a point *m* farther from the mirror than its principal focus, and in like manner the pencil NAB will have its focus at some point *n*, pencils intermediate between M and N having their foci at points intermediate between *m* and *n*. These points may be found by projection, as already described, or by the rule given for diverging rays.

The image *mn* is obviously an inverted picture of the object MN, and its size is to that of the object as the distance of the image from the mirror is to the distance of the object from it, that is, as *n*A is to NA, as may be found from projection, or from an experimental measurement of the distance, when a mirror is actually used.

From the doctrine of reflected diverging rays it follows, and may be proved by projection, that as the object MN approaches to the mirror, the image *mn* will recede from the mirror, till the object and image meet one another at the centre C, where they will have the same size. If MN still moves towards the mirror within C, the image *mn* will move outwards beyond C, and the image will now be larger than the object. If the object comes to the place *mn*, and is of the same size as *mn*, the image of it will be formed at MN, and will have the same size as MN. If the object goes still nearer the mirror, the image will go still farther off than MN, increasing in size. When the object reaches the principal focus half-way between C and D, the image will be infinitely distant; and when the object goes still nearer the mirror, as in fig. 14, where it is placed at MN, between the principal focus F and the mirror AB, Catoptrics.

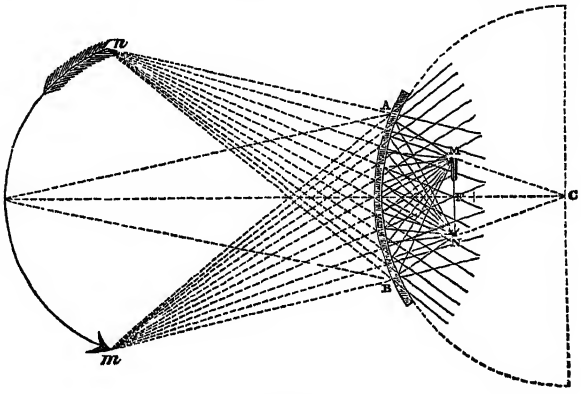

Fig. 14.

the rays will diverge in front of the mirror, and form an inverted *virtual image*, *mn*, behind the mirror. As the image MN approaches the mirror, the virtual image *mn* also approaches to it.

If we take a concave mirror of some size, and place before it any highly luminous or strongly-illuminated object, such as a plaster-of-Paris cast, we may obtain an interesting experimental proof of the preceding results. When the image is formed in front of the mirror, it will appear suspended in the air, and the effect of this will be greatly heightened if it is received on a cloud of thin blue smoke raised from a chafing-dish below the place of the image. By considering that as the object moves from MN to C (fig. 13), the image *mn* advances to C, we obtain an explanaplanation of the celebrated experiment with the dagger, in which a person with a drawn dagger striking at the mirror, is met by another person, viz., his own image, returning the stroke.

If the object MN is the sun, a small image of his disc will be formed at *mn*, in which are collected all the rays of light which fall upon the surface of the mirror. It will therefore have such a degree of heat as to melt even the hardest gems and metals. Such a mirror is called a burning mirror, from its effects. (See Burning Glasses.)

Formation of Images by Convex Mirrors.—As convex mirrors often form a part of household furniture, we are more familiar with their properties. They always form *erect* images of objects, which appear at a distance behind them. If AB (fig. 15) is a convex mirror whose centre is C, and principal focus F, and MN an object placed before it, it is obvious, from our description of fig. 11, that the diverging pencils MAB, NBA will diverge more after reflection, as if they came from virtual foci *mn* behind the mirror, so that our eye receiving such diverging rays will see an erect image *mn* of the object MN placed behind the mirror, and between F, its principal focus, and D. If MN approaches to AB, *mn* will approach it also, and if MN recedes from the

Catoptrics. mirror, *mn* will also recede from it, their relative sizes varying as their distances. When the object touches the mirror,

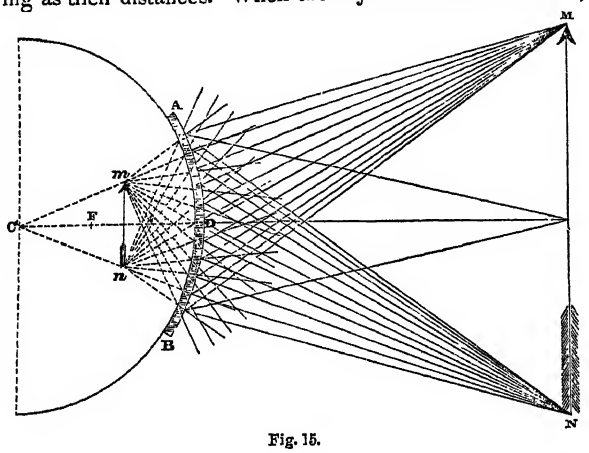

Fig. 15.

the image also touches it, and they are then exactly of the same size.

Formation of Images by Plane Mirrors.—Every person is familiar with the effects of a plane mirror, or looking-glass. The image of any object placed before it is seen behind it of the same size, in the same position, and at the same distance from the mirror. In order to understand this, let AB (fig. 16) be the mirror, MN the object, and E the eye of the observer, situated in any given position. Rays from M and N fall upon every part of the mirror, but MC, MD are the only ones from M which can reach the eye E, as all the rest are reflected either above or below the eye E. In like manner, the rays NF, NG are the only ones from N which can enter the eye. The extremity M of the object will therefore be seen in the direction E*m*, and the concourse or virtual focus of the reflected rays will, as shown in fig. 7, be at a point *m*, so situated, that if MA*m* is at right angles to the mirror, A*m* will be equal to AM. For the same reason, the point N will be seen at *n*, as far behind the mirror as N is before it; and it is obvious, from the parallelism of M*m* and N*n*, and the equality of the distance of the points M, *m*, and N, *n*, from AB, that *mn* is equal to MN.

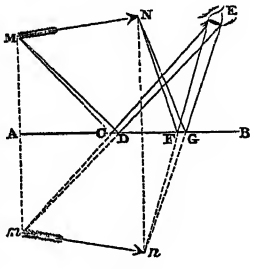

Fig. 16.

Kaleidoscope. If two plane mirrors are inclined to each other, as AC, BC (fig. 17), and an object MN placed between them, an eye situated so as to receive the reflected rays, will see a series of images of MN all arranged symmetrically. Behind AC, for example, an image *mn* will be formed, and behind BC another image M'N'. But as the rays which form these images again fall upon the mirrors, we shall see images of *mn* and M'N' formed by AC and BC; thus *mn* will be the image of *mn* formed by BC, and M"N" an image of M'N' formed by AC. In like manner, *m"n"* will be the image of *m'n'* formed by AC, and the image of M"N" formed by BC will also lie upon *m"n"*, so that we shall have two images at *m"n"* overlapping each other, and forming one exactly, if the angle ACB is exactly one-sixth part of 360°, or 60°; but if it is not, the compound image *m"n"* will be seen double and imperfect. The five images above described, reckoning the double one at *m"n"* as only one, will, together with the object MN, to which all the images are equal and similar, constitute a perfect equilateral triangle; so that if MN is a coloured and an irregular object, the symmetrical figure composed by

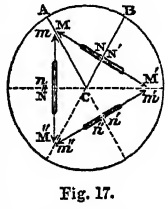

Fig. 17.

it, and all its images, will be highly beautiful and agreeable to the eye. If MN, in place of being perpendicular to the mirror BC, had been inclined to it, no pair of images would have formed a straight line, as in the figure, and the combination would have been more beautiful. This is the principle of the *kaleidoscope*, in as far as the multiplication and arrangement of the images is concerned; but this instrument has already been so admirably described by an eminent writer in our article KALEIDOSCOPE, that we must refer the reader to it for farther information. Dioptrics.

Formation of Images by Cylindrical Mirrors.—It is not easy, in a diagram, to represent the progress of rays in the formation of an image by a cylindrical mirror. As a cylinder is in one direction a plane mirror, in another a convex mirror, and in all others an elliptical one, the eccentricity of the ellipse passing through all degrees, from a circle to a straight line, different parts of a regular figure presented to such a mirror will appear of different sizes, and at different distances behind it. Part of the figure will have the same form and position as in a plane mirror, part as in a convex mirror, and the other parts of the image will have intermediate sizes and positions. Hence the image will be completely distorted. If the mirror is placed horizontally, the human face will appear of the right size from ear to ear, but contracted, as in a convex speculum, from brow to chin. Hence, if a distorted picture is properly drawn, and properly presented to the mirror—that is, if the cylinder is placed vertically before the picture—the image of the distorted picture will be rectified; the length between the ears will be contracted into the same proportional size as the shortness between the brow and the chin, and their shortness will remain unaffected. Such a distorted picture will be afterwards represented in the part of this article on Optical Instruments. Cylindrical mirrors.

In this section the objects are supposed to be lines, or surfaces composed of lines. But if the objects are solids, such as the human figure, or other bodies whose parts are at different distances from the mirror, the images of such objects are different from the images of the same objects seen by the eye, when the diameters of the mirrors exceed that of the pupil of the eye. This subject, which is of the highest importance in photography, will be treated in part ii., sect. 4.

PART II.—DIOPTRICS, OR THE REFRACTION OF LIGHT.

Dioptrics (from δια, *through*, and ὀπτομαι, *to see*) is that branch of optics which treats of the passage of light *through* transparent bodies, and, consequently, of the changes which it experiences in entering and quitting such bodies.

Sect. I.—ON THE REFRACTION OF LIGHT.

If we hold a drop of pure water or an irregular piece of clear glass in the sun's rays, each will have a sort of shadow like opaque bodies. Hence it follows that light has not passed freely through them, and must therefore have suffered some change in its direction, either while entering these bodies, or passing through them, or emerging from them. The change which it has suffered is called *refraction*, and the nature of this change will be discovered by observing the effects produced upon light by transparent bodies whose surface is flat and regular.

For this purpose let AB (fig. 18) be the surface of *water* in a vessel, and RC a ray or pencil of light proceeding from a candle or from the sun, through a small hole, and falling upon the water at C. Part of this light will be *reflected* in the direction C*r*, so that the angle *r*CP is equal to RCP, PQ being a line perpendicular to the water at C; but the greater part of the light will enter the water at C, and in place of going straight on to *e*, it will be *bent*

Dioptrics.

or refracted at C, or the ray R*e* will be *broken back* at C, and proceed in a straight line to E. Drawing a circle PAQB round C as a centre, and from the point E, where the refracted ray cuts it, drawing EK parallel to PQ, it was found by Snellius that CD was to CE or C*e* as 3 to 4; and we have shown in the "history of optics," that if R*f* and EF are drawn perpendicular to PQ, CD is to C*e* as EF is to R*f*. But R*f* is the sine of the *angle of incidence* RCP, and EF is the sine of the angle ECQ, which is called the *angle of refraction*. Now, Snellius discovered, by numerous experiments, that whatever was the magnitude of the angle of incidence RCP, the magnitude of the angle of refraction was such that CD was to C*e* as 3 to 4, or in a constant ratio. Hence it follows, that the sines of the angles of incidence and refraction R*f* and EF, are, in the case of water, in the constant ratio of 4 to 3.

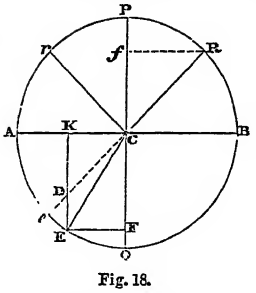

Fig. 18.

Snellius did not mention the *constant ratio of the sines*, but merely the *constant ratio of* CD *and* C*e*, which is the same thing; and he preferred the use of that ratio for the following reason:—When a luminous body is placed at E below water, and its light passes through a small aperture at C, it is found to be refracted or bent into the direction CR, so as to be seen by an eye at R, in the direction R*e*, elevated from E to D.

As the incident ray RC approaches to the perpendicular PQ, the refracted ray CE approaches also to the perpendicular, and CD becomes less and less, and when RC coincides with PC, or when the ray is incident perpendicularly, the refracted ray CE will coincide with CQ, or the incident ray will suffer no refraction at C. When the angle of incidence RCP increases, and RC approaches to the surface of the water CB, the angle of refraction ECQ will also increase, the line CD will increase, and the refracted ray approach also to the surface CA, and when RC coincides with BC, C*e* will coincide with CA, and no light whatever will enter the water, but it will all be reflected. When C*e* coincides with CA, CD will be 3, and D will coincide with K.

Such are the phenomena and law of refraction when light passes from a rare medium such as *air*, into a dense medium such as *water*, the ray being always *refracted towards* the perpendicular, according to the fixed law already described. Let us now suppose, that the ray of light passes from a dense medium, such as water, placed above AB (fig. 19), into a rare medium, such as air placed below AB, and let PQ be a perpendicular to the surface of the water at C. It is found by experiment that the ray neither goes straight on to *e*, nor is refracted towards the perpendicular as before, but is refracted from the perpendicular into the direction CE; so that, if the line KED is drawn through E, parallel to PQ, and cutting the original direction of the ray R*e* prolonged, in the point D, CD will be to CE or C*e*, as 4 to 3, and in a constant ratio, or R*f* the sine of the angle of incidence will be to EF the sine of the angle of refraction in the constant ratio of 4 to 3. When the ray RC coincides with PC, so that the angle of incidence is nothing, the angle of refraction will also be nothing, and the refracted ray CE will coincide with CQ, the incident ray having gone straight on without experiencing any refraction; but when the angle of incidence increases, and RC approaches towards BC, the refracted ray CE will approach to CA, which it will reach long before R reaches B. When CE reaches CA, the ray RC will no longer emerge from the water into the air, but will suffer *total reflection* at C; and at every angle of incidence beyond that at which this total reflection commences, the light will continue to be totally reflected till RC coincides with RB.

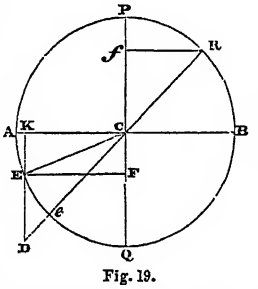

Fig. 19.

If we repeat all the above experiments with *plate* or *crown glass*, in place of *water*, we shall find the very same phenomena reproduced, with the difference only, that the constant ratio of CD to C*e*, or of the sines R*f* to EF, in place of being as 3 to 4 in one case (see fig. 18), and 4 to 3 in the other (see fig. 19), will be as 2 to 3, and as 3 to 2; or in the case of water the ratio will be as 1 to 1·333, and in glass as 1 to 1·500. The number 1·333 is called the *index of refraction* for *water*, and 1·500 the *index of refraction* for *glass*. In like manner, it is found that the index of refraction for *tabasheer* is 1·111, being less than that for water; for flint glass 1·600, for diamond 2·500, and for chromate of lead about 3·00. Hence it follows, that bodies refract light in different degrees, measured by their indices of refraction. In order to have an ocular representation of the different degrees of refraction, we have drawn in fig. 20 the different refracted rays, corresponding to a given incident ray RC, supposing the surface AB to be first *air* (the medium above it being a vacuum), then *tabasheer*, then *water*, then *flint-glass*, then *diamond*, and, lastly, *chromate of lead*.

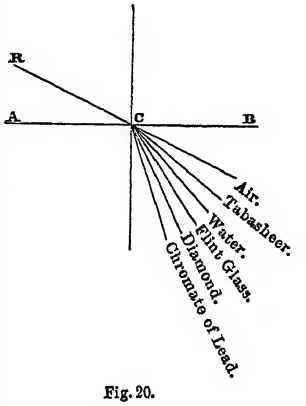

Fig. 20.

When the index of refraction of any body is known, we can easily ascertain the progress of a ray of light which falls upon such a body, and its direction after quitting the body. The following example of this we shall give for plate-glass. Let AB (fig. 21) be the surface of a piece of plate-glass whose index or ratio of refraction is as 2 to 3, or as 1 to 1·50, and let a ray of light RC fall upon it at C. Prolong RC to *e*, and upon a scale of equal parts take in the compasses CD, equal to 10 of these parts, and C*e* equal to 15, or CD equal to 2, and C*e* to 3 parts. Upon C as a centre, with the radius C*e*, describe the semicircle A*e*B, and through D draw KDE, perpendicular to AB, and meeting the semicircle in E; join CE, and CE will be the refracted ray. When the ray passes from a denser to a rarer medium, as in fig. 19, C*e* is made equal to 10, and CD to 15, and KD being drawn perpendicular to AB, and a line drawn from C to the point E, where DK cuts the circle, CE will be the refracted ray. This method is obviously much more simple and elegant than when we use the sines of the angles. When E and K coincide with A (fig. 19), DK becomes a tangent to the circle at A, and the light suffers total reflection.

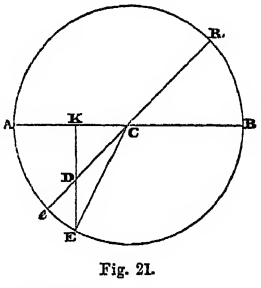

Fig. 21.

If the preceding experiments are repeated with various solids and fluids, it will be found that the same law of refraction takes place with all of them; the index of refraction varying more or less in each; the refractive power being least in the gases, and less in fluids, generally speaking, than in solids, as will be seen in the following table of refractive powers, collected from various authors, and determined by methods possessing various degrees of accuracy.

Dioptrics.

Table of the Refractive Powers of Gases, Fluids, and Solids.[1]

Dioptrics.

	Index of Refraction.	
A vacuum	1·0000	

GASES.[2]

Hydrogen	1·000138	
Oxygen	1·000272	
Atmospheric air	1·000294	
Azote	1·000300	
Nitrous gas	1·000303	
Carbonic oxide	1·000340	
Ammonia	1·000385	
Carburetted hydrogen	1·000443	
Carbonic acid	1·000449	
Muriatic acid	1·000449	
Hydrocyanic acid	1·000451	
Nitrous oxide	1·000503	
Sulphuretted hydrogen	1·000644	
Sulphurous acid	1·000665	
Olefiant gas	1·000678	
Chlorine	1·000779	
Protophosphuretted hydrogen	1·000789	
Cyanogen	1·000834	
Muriatic ether	1·001095	
Phosgene	1·001159	
Vapour of sulphuret of carbon	1·001500	
Vapour of sulphuric ether, (boiling point at 35° centig.)	1·001530	

All the preceding observations were made by M. Dulong, excepting that on atmospheric air, which we owe to M. Biot.

FLUIDS AND SOFT SOLIDS.

Ether expanded by heat to thrice its volume	1·0570	Br.
Volatile new fluid discovered by Sir D. Brewster in cavities in topaz (*Brewstoline*)	1·1311	Br.
Volatile new fluid discovered by Sir D. Brewster in amethyst, at 83½° Fahr. (*amethystoline*)	1·2106	Br.
Second new fluid discovered by Sir D. Brewster in topaz	1·2047	Br.
Nitrous oxide, liquified by pressure.... much less than water		F.
Muriatic acid gas, do..... nearly equal much less than water		F.
Carbonic acid gas, do..... nearly equal much less than water		F.
Chlorine liquified by pressure rather less than water		F.
Cyanogen liquified by pressure perhaps less than water		F.
Do. do. do.	1·316	Br.
Sulphurous acid, liquified by pressure..... same as water		F.
Water	1·336	N. W. Br.
„ fixed line E[3]	1·33585	Fr.
Aqueous humour of the eye	1·3366	Br.
„ „ of haddock	1·341	Br. Y.
Vitreous humour of eye	1·336	W.
	1·3394	Br.
„ „ lamb	1·345	Br. Y.
„ „ pigeon	1·353	Br. Y.
Saliva	1·339	Br. Y.
Expectorated mucus	1·339	Br. Y.
Salt water	1·343	Br.

	Index of Refraction.	
Vinegar, distilled	1·344	Eu.
	1·372	H.
	1·347	Br. Y.
Acetic acid	1·396	Br.
Jelly-fish (*Medusa æquorea*)	1·345	Br.
White of an egg	1·351	Eu.
„ a hen's do	1·359	Br. Y.
	1·361	Br.
Port wine	1·351	Br. Y.
Human blood	1·354	Br. Y.
Saturated solution of alum and water	1·356	He.
Oil of boxwood	1·356	Br. Y.
Ether	1·358	W.
	1·374	Br. Y.
Albumen	1·36	W.
Brandy	1·366	Br. Y.
Rum	1·360	Br. Y.
Oil of ambergris	1·368	Br.
	1·379	Br. Y.
Alcohol, sp. gr. 0·866	1·371	C.
„ rectified spirits	1·372	He.
	1·374	Br.
	1·377	Br. Y.
Saturated solution of salt	1·375	C.
Muriatic acid, sp. gr. 1·134	1·392	He.
	1·391	Br. Y.
„ „ strong	1·401	Br.
„ „ highly concentrated	1·4098	Bi.
Oil of wine	1·379	Br.
Sweet spirit of nitre	1·384	He.
Malic acid	1·395	Br.
Pus	1·404	Br. Y.
Nitrous acid	1·396	Br.
	1·404	Br. Y.
Crystalline lens of man, outer coat	1·3767	Br.
„ „ middle coat	1·3786	Br.
„ „ centre	1·3970	Br.
Crystalline lens of lamb's eye, outer coat	1·386	Br. Y.
„ „ middle coat	1·428	Br. Y.
„ „ centre	1·436	Br. Y.
Crystalline lens of pigeon	1·406	Br. Y.
„ „ haddock's eye, outer coat	1·410	Br. Y.
„ „ centre	1·439	Br. Y.
Crystalline lens of the ox.	1·380	W.
	1·447	W.
	1·463	Eu.
Solution of potash, sp. gr. 1·416; fixed line E	1·40563	Fr.
Nitric acid, sp. gr. 1·48	1·410	Br. Y.
	1·410	W.
	1·412	C.
Hydrate of soda, melted by heat	1·411	Br. Y.
Hydrophosphoric acid, do	1·423	Br. Y.
Phosphoric acid fluid	1·426	Br.
Yolk of a fresh egg	1·428	Br. Y.
Sulphuric acid, sp. gr. 1·7.	1·430	He.
	1·435	W.
	1·440	Br.
Oil of rhue	1·433	Br.
	1·449	Br. Y.
Phosphorous acid	1·437	Br. Y.
Hydrophosphoric acid, cold	1·442	Br.
Spermaceti, melted	1·446	W.
	1·444	Br. Y.
Oil of wax	1·452	C.
Oil of wormwood	1·453	Br.
Oil of wormwood, boiling	1·4416	M.
Bees' wax, melted	1·453	Br. Y.

	Index of Refraction.	
Bees' wax, melting	1·4503	M.
„ boiling	1·542	W.
Oil of camomile	1·457	Br.
Oil of lavender	1·457	Br.
	1·467	W.
	1·475	Br. Y.
Tallow, melted	1·460	W.
White wax, melted	2·462	Br.
Oil of poppy	1·467	Br.
	1·483	Br. Y.
Oil of peppermint	1·468	W.
	1·473	Br. Y.
Oil of rosemary	1·469	Br.
	1·472	Br. Y.
Oil of spermaceti	1·470	Br.
	1·473	Br. Y.
Oil of almonds	1·470	W.
	1·481	Br.
	1·483	Br. Y.
Oil of turpentine, rectified	1·470	W.
Oil of turpentine	1·475	Br.
	1·476	Br. Y.
	1·482	C.
„ „ common	1·476	W.
	1·486	He.
„ „ sp. gr. 0·885, fixed line E	1·47835	Fr.
Oil of olives, sp. gr. 0·913	1·470	Br.
	1·4705	He.
	1·476	Br. Y.
Oil of bergamot	1·471	Br.
	1·473	Br. Y.
Oil of birch, distilled from spermaceti	1·470	Br. Y.
	1·471	Br. Y.
Oil of beech ?	1·471	Br.
Oil of juniper	1·473	Br.
Butter, cold	1·474	Br. Y.
Palm oil	1·480	W.
Oil of rape-seed	1·475	Br.
Naphtha	1·475	Br. Y.
Essence of lemon	1·476	W.
Oil of dill-seed	1·477	Br.
	1·487	Br. Y.
Oil of thyme	1·477	Br.
	1·486	Br. Y.
Oil of cajeput	1·478	Br. Y.
Naples soap	1·483	Br.
Oil of mace, melted	1·479	Br. Y.
Oil of spearmint	1·481	Br. Y.
	1·481	Br.
Oil of lemon	1·490	Br. Y.
	1·481	Br.
Oil of pennyroyal	1·482	Br.
Linseed oil, sp. gr. 0·932	1·485	Br. Y.
	1·482	N.
	1·485	W.
Oil of savine	1·487	Br Y.
Oil of juniper	1·482	Br.
	1·482	Br. Y.
Train oil	1·491	Br. Y.
Oil of wormwood	1·485	Br. Y.
Castor oil	1·489	Br. Y.
	1·485	Br. Y.
Florence oil	1·490	Br.
Oil of fenugreck	1·487	Br.
	1·488	Br. Y.
Oil of hyssop	1·487	Br.
	1·495	Br. Y.
Windsor soap	1·487	Br. Y.
Nut oil, perhaps impure	1·490	He.
	1·491	Br. Y.
Tallow, cold	1·492	Br. Y.
Oil of caraway seeds	1·483	Br. Y.
	1·491	Br.

[1] In the above Table, the letter *N* affixed to any index of refraction, indicates that the observation was made by Newton; *H*, Hauksbee; *Eu*, Euler; *M*, Malus; *C*, Cavallo's table; *Ru*, Rudberg; *Bi*, Biot; *Po*, Potter; *Ze*, Zeiher; *Dx*, Descloiseaux; *Bosc*, Boscovich; *Fr*, Fraunhofer; *He*, Sir John Herschel; *F*, Mr Faraday; *Hai*, Haidinger; *Mil*, Miller; *W*, Wollaston; *S*, Senarmont; *Au*, Augstrom; *Heu*, Heusser; *Br*, Sir David Brewster; and *Br. Y*, by Dr Young, who calculated the indices from Sir David Brewster's observations.

[2] Taken when the temperature was 32° Fahr., and the barometer at 29·922.

[3] The fixed line E is given in this Table for several substances, as it is in the green space and nearly the mean ray.

Dioptrics.

	Index of Refraction.	
Oil of marjoram	1·490	Br. Y.
	1·491	Br.
Oil of nutmeg	1·491	Br. Y.
	1·497	W.
Oil of angelica	1·491	Br. Y.
	1·493	Br.
Bees' wax	1·507	Br. Y.
„ „ cold	1·492	
„ white wax, cold	1·535	W.
Balsam of sulphur	1·494	Br. Y.
	1·497	Br.
Honey	1·495	Br. Y.
Grass oil	1·496	Br.
Treacle	1·500	W.
Oil of beech nut	1·500	
Oil of rhodium	1·500	Br.
	1·505	
	1·503	
Spermaceti, cold	1·503	Br. Y.
	1·535	W.
Oil of pimento	1·503	Br. Y.
	1·510	
	1·507	Br.
Oil of amber	1·505	W.
	1·507	Br. Y.
Bird lime	1·506	
Oil of sweet fennel seeds	1·506	Br.
	1·507	Br. Y.
Balsam of capivi	1·507	W.
	1·515	Br. Y.
Canada balsam	1·528	W.
	1·532	Br. Y.
	1·549	Br.
Oil of cinnamon	1·508	Br.
Oil of mace	1·519	Br. Y.
Oil of sassafras	1·522	
	1·532	Br.
	1·536	W.
	1·544	Eu.
Balsam of Gilead	1·529	Br. Y.
Oil of cloves	1·535	W.
	1·539	Br. Y.
Oil of cashew nut	1·536	Br. Y.
Oil of anise seed	1·536	Br. Y.
	1·601	Br.
Petroleum	1·544	Br. Y.
Oil of tobacco	1·547	Br.
Balsam of styrax	1·584	Br.
Oil of cinnamon	1·534	Eu.
	1·589	
	1·604	Br. Y.
	1·632	
Balsam of Peru, mean	1·600	Br.
Essential oil of bitter almonds	1·603	
Oil of cassia	1·626	Br. Y.
	1·631	
	1·641	
	1·647	Br.
Sulphuret of carbon	1·678	
Muriate of antimony, variable, about	1·8	W.

SOLIDS.

Tabasheer from Vellore	1·1111	Br.
„ „ Nagpore	1·1454	
„ „ ditto	1·1503	
„ whitest kind	1·1825	
Ice	1·3085	W.
	1·310	
Cryolite	1·344	Br.
	1·349	
Sphene	β 1·361	Mil.
Carbonate of potash, lowest refr.	1·379	Br.
Hydrophane, dry, red ray	1·382	S.
„ full of water	1·438	
Gluten of wheat, dried	1·426	Br. Y.
Fluor spar	1·433	W.
	1·436	Br.

	Index of Refraction.	
Quartz, melted, red rays	1·453	S.
Hyalite, red rays	1·455	
Alum	1·457	W.
„ sp. gr. 1·714	1·458	W.
	1·488	Br. Y.
Sulphate of Magnesia	1·465	Br.
	1·488	
Borax, sp. gr. 1·7149	1·467	N. C.
	1·475	Br.
Fluellite	1·47	W.
Gum-arabic, sp. gr. 1·375	1·467	N.
Gmelinite	1·474	Br.
Opal, partly hydrophanous	1·479	
Arseniate of soda, least	1·479	Ha.
„ „ greatest	1·481	
Sulphate of ammonia and magnesia	1·476	S.
„ „	β 1·483	Br.
Camphor	1·487	W.
	1·496	Br. Y.
Sulphate of potash and manganese	β 1·487	S.
„ „ nickel	β 1·4905	
„ „ cobalt	β 1·4655	
„ ammonia and nickel	β 1·499	
„ „ cobalt	β 1·4925	
„ „ zinc	β 1·491	
Obsidian	1·488	Br.
Levo- and dextro-tartrate of potash and soda	1·4929	He.
β red rays	1·4985	
β green do.		
Levo-tartrate of soda and ammonia	β 1·490	S.
Dextro „ „	β 1·495	
Iceland spar, ext.	1·488	W.
„ „ ditto	1·4833	M.
„ „ fixed line E, do.	1·4887	Ru.
„ „ ord.	1·657	W.
„ „ ord.	1·6543	M.
„ „ fixed line E, ord.	1·6636	Ru.
„ „ ord.	1·667	N.
Sulphate of iron, greatest	1·494	Br.
Sulphate of potash	1·509	Br.
„ 1 axis, ord.	1·493	S.
„ „ ext.	1·501	
„ 2 axes	β 1·494	
Oxalic acid	β 1·499	Mil.
Rochelle salt, mean, green	1·4985	He.
„ „ red	1·4929	He.
„ tartrate of potash and soda	1·515	Br.
Yolk of an egg, dry	1·500	Br. Y.
Triple oxalate of chromium and potash, least	1·506	Br.
„ greatest	1·605	
Glass plate, English	1·500	W.
„ French	1·50	
„ English, ext.	1·5133	He.
red ray	1·514	Bosc.
Glass plate, Dutch	1·517	W.
„ crown	1·525	
„ crown, prism Dollond, ext. red ray	1·526	He.
„ crown, prism Dollond.	1·5109	Br.
„ crown, Fraunhofer, No. 13, sp. gr. 2·535, fixed line E.	1·5314	Fr.
Glass, crown, Fraunhofer, No. 9, fixed line, sp. gr. 2·535	1·5330	Fr.
Do. do. sp. gr. 2·756, fixed line E.	1·5631	Fr.
Glass, bottle	1·582	Br.
Starch, dry	1·504	Br. Y.
Stilbite	1·508	Br.
Gum-scammony	1·510	Br. Y.
Gum-arabic	1·512	Br.
„ not quite dry	1·513	Br. Y.
	1·514	W.
Human cuticle	1·514	W.
	1·517	

	Index of Refraction.	
Nitre, least index	1·335	Br.
„ greatest index	1·514	Br.
	α 1·5052	
	β 1·5046	
	γ 1·330	
Dantzic vitriol, sulphate iron,	1·515	N.
Phosphate of ammonia, ord.	1·5155	S.
„ potash, ext.	1·4765	
„ „ ord.	1·5075	
„ „ ext.	1·4685	
Nadelstein from Faroe	1·5153	Br.
Mesotype, least	1·516	Br.
„ greatest	1·522	
Sulphate of zinc, ord. refr.	1·517	Br.
	β 1·4845	Dx.
Myrrh gum	1·517	Br. Y.
	1·526	
Tartaric acid, least	1·518	Br.
„ greatest	1·575	
Wavellite	1·52	W.
Gum-dragon (tragacanth),	1·520	Br
	1·66	W.[1]
Glass—borax, 1; silex, 2	1·528	Br.
Gum or shell-lac	1·521	W.
	1·525	Br. Y.
	1·528	
Caoutchouc	1·524	W.
	1·534	Br.
	1·557	Br. Y.
Tartrate of potash, neutral,	β 1·526	Mil.
Citric acid	1·527	Br.
Leucite	1·527	Br.
Sulphate of lime	α 1·5297	Au.
„ „ yellow ray D	β 1·5227	
	γ 1·5206	
Crystalline of ox and fish, dried	1·530	W.
Pitch	1·531	W.
	1·581	Br. Y.
	1·586	Br.
Sulphate of copper, least refraction	1·531	
	1·552	
Olibanum gum	1·532	Br. Y.
	1·544	Br.
Orthose	β 1·5225	Dx.
Glass of phosphorus, phosphoric acid fused	1·532	Br.
Solid phosphoric acid	1·544	
Glass of borax, fused borax	1·532	
Manna	1·533	Br. Y.
Arragonite, ext. index	1·5348	M.
„ ord.	1·6931	
„ γ 1st axis of elasticity	1·5326	Ru.
„ β 2d ditto	1·6863	
„ α 3d ditto	1·6908	
„ axes of elasticity	α 1·6859	D x
	β 1·6815	
	γ 1·5301	
Arseniate of potash	1·535	W.
Fahlunite	1·535	Br.
Elemi gum	1·535	W.
	1·547	Br. Y.
	1·550	Br. Y.
Mastic gum	1·535	W.
	1·549	Br. Y.
	1·568	Br.
Anime gum	1·535	W.
	1·546	Br. Y.
Copal gum	1·535	W.
	1·549	Br.
	1·553	Br. Y.
Sugar, white	1·536	W.
	1·541	Br. Y.
„ melted	1·548	Br. Y.
Agate, white, red rays	1·537	S.
Dichroite, iolite, cordierite, from Ceylon, axes of elasticity	α 1·5433	Dx.
	β 1·5413	
	γ 1·5371	
Felspar	1·536	Br.
Mellite, least	1·538	Br.
„ greatest	1·556	

[1] Dr Wollaston informed us that he had mistaken Dragon's-blood for Gum-dragon.

Dioptrics.

	Index of Refraction.	
Mellite, ord.	1·5455	Dx.
„ ext.	1·5255	
Nepheline, ord.	1·5365	
„ ext.	1·5415	
Juniper gum	1·538	Br.
	1·541	Br. Y.
Carbonate of barytes, least	1·540	Br.
Formiate of strontian, axes of elasticity. α	1·54148	Dx.
β	1·52616	
γ	1·48664	
Boxwood	1·542	W.
Apophyllite	1·5431	He.
Carbonate of strontian, least	1·543	Br.
„ „ greatest	1·700	
Rock-salt, sp. gr. 2·143	1·557	
Chio turpentine, mean	1·551	
Sagapenum gum	1·545	Br. Y.
Turpentine	1·545	
Burgundy pitch, mean	1·558	
Gum-thus, mean	1·550	Br.
Amethyst	1·562	W.
Quartz, ord. ray	1·5484	M.
„ ext.	1·5582	M.
„ ord., line E	1·5471	R.
„ ext., ditto	1·5563	R.
Amber	1·547	W.
„ sp. gr. 1·04	1·556	N.
Pennine, ord.	1·576	Hai.
„ ext.	1·575	
Resin, mean	1·554	Br.
Glue, nearly hard	1·553	Br. Y.
Chalcedony	1·553	Br.
Comptonite	1·553	Br.
Opium	1·559	Br. Y.
	1·57	W.
Parisite, ord.	1·569	S.
„ red rays, ext.	1·670	
Hyposulphate of lime, mean red ray	1·561	He.
„ „ mean green	1·566	He.
Dragon's-blood	1·562	Br. Y.
Horn	1·565	Br.
	1·58	W.
Wernerite, ext.	1·563	Br.
„ ord.	1·594	
Baryto-calcite, least	1·565	
„ greatest	1·701	
Glass, pink-coloured	1·570	
Staurotide	1·5726	Mil.
Assafœtida	1·575	Br. Y.
Arseniate of ammonia, ord.	1·5775	S.
„ „ ext.	1·524	
„ potash, ord.	1·5915	
„ „ ext.	1·5365	
Flint-glass, var. specimens	1·576	Br.
	1·578	He.
	1·583	W.
„ extreme red	1·584	He.
	1·594	Bosc.
	1·596	Br.
	1·601	He.
	1·604	Br. Bosc.
Do. Fraunhofer, No. 3, line E.	1·6145	Fr.
„ No. 30, line E	1·6374	
„ No. 23, ditto.	1·6405	
„ No. 13, ditto	1·6420	
Andalusite, green	1·624	Mil.
Prussiate of potash	1·586	Br.
Anhydrite, ord.	1·5772	Bi.
„ ext.	1·6219	Bi.
„ axes of elasticity α	1·614	Mil.
β	1·576	
γ	1·571	
Gum-ammoniac	1·585	Br.
Hyposulphite of lime, least	1·583	He.
„ „ greatest	1·628	
Emerald	1·585	Br.
„ green ray, ord.	1·5841	Dx.
„ „ ext.	1·5780	
Benzoic gum, mean	1·591	W.

	Index of Refraction.	
Tortoise-shell	1·591	Br.
Guiacum gum	1·596	W.
	1·600	Br. Y.
	1·619	Br.
Beryl, ord.	1·582	D.
„ ext.	1·576	
Balsam of Tolu	1·60	W.
„ „ mean	1·618	Br.
Siliceo-carbonate of zinc and iron, least	1·6005	Br.
Ditto, ditto, greatest	1·8477	Br.
Hopeite, ord.	1·601	Br.
Glass, ruby-red	1·601	
Meionite	1·606	
„ ord.	1·5955	Dx.
„ ext.	1·5595	
Iron sinter	1·606	Br.
Glass, purple-coloured	1·608	
Resin of jalap	1·608	Br. Y.
Hyposulphite of strontian, least	1·608	He.
Ditto, greatest	1·651	
Topaz, colourless	1·6102	Bi.
„ 1st axis of elasticity	1·6145	Ru.
„ 2d ditto ditto	1·6167	Ru.
„ 3d ditto ditto	1·6241	
„ bluish, from Cairngorm	1·624	Br.
„ Brazil, ord.	1·6323	Bi.
„ „ ext.	1·6401	Bi.
„ blue Aberdeen	1·636	Br.
„ yellow	1·638	
„ red	1·652	
„ Brazil yellow, for green rays α	1·6240	Dx.
β	1·6174	
γ	1·6150	
Siliceo-carbonate of zinc from Aachen, least	1·6173	Br.
„ greatest	1·6395	Br.
„ from Bohemia, least	1·600	
„ „ greatest	1·848	
Castor	1·623	Br.
Sulphate of barytes, ord.	1·6352	M.
„ „ ext.	1·6468	M.
„ „ ord.	1·6201	Bi.
Do. ord. yellow, green rays	1·6460	He.
„ „	1·646	W.
Muriate of ammonia	1·625	Br.
Aloes	1·634	Br. Y.
Glass, opal-coloured	1·635	Br.
Tourmaline, line D, ord.	1·6366	Fr.
„ „ ext.	1·6193	
Euclase, ord.	1·6429	Bi.
„ ext.	1·6630	Bi.
Sulphate of strontian	1·649	Br.
Mother-of-pearl	1·653	
Spargelstein	1·657	
Epidote, least	1·661	
„ greatest	1·703	
Chrysolite, least	1·660	
„ greatest	1·685	
„ (cymophane), axes of elasticity α	1·7565	Dx.
β	1·7484	
γ	1·7470	
Dioptase, ord.	1·667	
„ ext.	1·723	
Phenakite, ord.	1·652	S.
„ ext.	1·672	
Chloruret of sulphur	1·67	He.
Nitrate of bismuth, least	1·67	
„ „ greatest	1·89	
Glass, orange-coloured.	1·695	Br.
Boracite	1·701	
Glass, tinged red with gold	1·715	
„ deep red	1·729	
Euchroite, least	1·709	
Nitrate of silver, least	1·729	
„ „ greatest	1·788	
Chromate of potash, yellow, β	1·722	S.
Hyposulphite of soda and silver, least	1·735	He.

	Index of Refraction.	
Hyposulphite of soda and silver, greatest	1·785	He.
Idocrase, ord.	1·7205	Dx.
„ ext.	1·7185	
Nitrate of soda, ord.	1·506	
„ ext.	1·366	
Apatite, ord.	1·646	He.
„ ray D, ext.	1·641	
Axinite	1·735	Br.
Nitrate of lead	1·758	
Cinnamon stone	1·759	
Chrysoberyl	1·760	
Spinelle	1·756	He.
	1·761	Br.
	1·812	W.
Felspar, greatest refr.	1·764	Br.
Sapphire, white	1·768	W.
„ blue	1·794	Br.
„ ord.	1·769	
„ ext.	1·762	
Rubellite	1·768	He.
	1·779	
Ruby	1·779	Br.
Zircon, orange coloured	1·782	
Glass lead (flint)	1·787	Ze.
Pyrope	1·792	Br.
Labrador hornblende	1·80	He.
Arsenic	1·84	W.
Garnet	1·815	Br.
Borate of lead, fused, extreme red ray	1·866	He
Leadhillite β	1·8828	Dx.
Sulphate of lead	1·925	Br.
Withamite, least	1·931	
„ greatest	1·960	
Glass—lead 2, sand 1	1·987	W.
Zircon, least refraction	1·961	Br.
„ greatest ditto	2·015	Br.
Sulphur, native	1·958	Haüy.
	2·008	Br. Y.
	2·04	W.
	2·115	Br.
„ „ melted	2·148	Br.
Calomel, ord.	1·96	S
„ ext.	2·60	
Tungstate of lime, least	1·970	Br.
„ „ greatest	2·129	
Glass—lead 3, flint 1	2·028	Ze.
Carbonate of lead α	2·0745	Dx.
β	2·0728	
γ	1·798	
Scaly oxide of iron	2·1	Y.
Glass of antimony	1·889	N.
	1·980	W.
	2·15	Po.[1]
	2·216	Br.
Silicate of lead, atom to atom, extreme red	2·123	He.
Phosphorus	2·125	Br. Y.
	2·224	Br.
Blende	2·260	Br.
Nitrate of lead, ord.	2·322	He.
Diamond, sp. gr. 3·4	2·439	N.
	2·470	Br.
„ brown coloured.	2·487	Br.
	2·775	
Plumbago	from 2·04 to 2·44	W.
Chromate of lead	2·479	Br.
Do. another kind, least refr.	2·503	
Do. another kind, do.	2·508	
Chromate of lead, another kind, greatest refraction	2·974	Br.
„ another kind, do.	2·926	
„ „ ord.	2·554	Mil.
„ „ ext.	2·493	
Octohedrite	2·500	Br.
Realgar, artificial	2·549	
Red silver ore	2·564	
Greenockite, ord.	2·688	

[1] Deduced from its polarizing angle, which was 65°.

Dioptrics. If light is regarded as consisting of material particles, it must move with greater velocity in bodies than *in vacuo*, in the proportion of the sines to which the refraction of these bodies is proportional. The power of bodies, therefore, to refract and reflect light, must be inversely proportional to their specific gravities; for if a body of small specific gravity has the same index of refraction as a body of great specific gravity, the former must have exercised a greater absolute force upon light than the latter.

On the hypothesis of emission, it has been shown by Sir Isaac Newton that the absolute refractive power of bodies is proportional directly to the square of the cosine of their maximum angle of refraction, and inversely to their specific gravity; that is, calling R the absolute refractive power, m the index of refraction, and D the density of the body, we shall have $R=\frac{m^2-1}{D}$, a formula by which the following table of absolute refractive powers has been computed. The numbers marked *Dulong* were, we believe, computed by Sir John Herschel from the refractive indices given by Dulong in the preceding table. Dioptrics.

Table of Absolute Refractive Powers.

	Index of Refraction.	
Tabasheer	0 0976	Brewster.
Cryolite	0·2742	Brewster.
Fluor spar	0·3426	Brewster.
Oxygen	0·3799	Dulong.
Sulphate of barytes	0·3829	Dulong.
	0·3979	Newton.
Sulphurous acid gas	0·4455	Dulong.
Nitrous gas	0·4491	Dulong.
Air	0·4528	Dulong.
	0·4530	Biot.
	0 5208	Newton.
Carbonic acid gas	0·4537	Dulong.
Azote	0·4734	Dulong.
Chlorine	0 4813	Dulong.
Glass of antimony	0·4864	Newton.
Nitrous oxide	0·5078	Dulong.
Phosgen	0·5188	Dulong.
Selenite	0 5386	Newton.
Carbonic oxide	0 5387	Dulong.
Quartz	0·5415	Malus.
Rock-crystal	0·5450	Newton.
Common glass	0 5436	Newton.
Muriatic acid gas	0 5514	Dulong.
Sulphuric acid	0·6124	Newton.

	Index of Refraction.	
Calcareous spar	0 6424	Malus.
	0·6536	Newton.
Nitre	0·6440	Brewster.
	0·7079	Newton.
Muriate of soda	0·6177	Newton.
	0 7100	Brewster.
Alum	0·6570	Newton.
Nitric acid	0·6676	Brewster.
Borax	0·6716	Newton.
Hydrocyanic acid	0·7366	Dulong.
Ruby	0·7389	Brewster.
Sulphate of iron	0·7551	Newton.
Muriatic ether vapour	0 7552	Dulong.
Brazilian topaz	0·7586	Brewster.
Rain water	0 7845	Newton.
Flint glass, mean	0·7986	Brewster.
Cyanogen	0 8021	Dulong.
Sulphuretted hydrogen	0·8419	Dulong.
Gum-arabic	0 8574	Newton.
Sulphuret of carbon vapour	0·8743	Dulong.
Sulphuric ether vapour	0·9138	Dulong.
Proto-sulphuretted hydrogen	0·9680	Dulong.

	Index of Refraction.	
Ammonia	1·0032	Dulong.
Alcohol, rectified	1·0121	Dulong.
Carbonate of potash	1·0227	Brewster.
Chromate of lead	1·0436	Brewster.
Olefiant gas	1·0654	Dulong.
Muriate of ammonia	1 0788	Brewster.
Carburetted hydrogen	1·2204	Dulong.
Camphor	1·2551	Newton.
Oil of olives	1·2607	Newton.
Oil of linseed	1·2819	Newton.
Spirit of turpentine	1·3222	Newton.
Bees' wax	1·3308	Malus.
Amber	1·3654	Newton.
Octohedrite	1·3816	Brewster.
Bi-sulphuret of carbon	1·4294	Brewster.
Diamond	1·4566	Newton.
Oil of cinnamon (sp. gr. 1·044)	1·4944	Brewster.
Oil of cassia (sp. gr. 1·044)	1·6184	Brewster.
Realgar	1·6666	Brewster.
Ambergris	1·7000	Brewster.
Sulphur	2 2000	Brewster.
Phosphorus	2·8857	Brewster.
Hydrogen	3·0953	Dulong.

The results given in the preceding tables are susceptible of increased accuracy, not only by taking accurate measures of the indices of refraction of the bodies, in relation to the fixed line E of the spectrum, but also by obtaining more accurate measures of their specific gravities.

Sect. II.—On the Refraction of Rays by Bodies with Plane and Spherical Surfaces.

Having shown how to find the refracted ray, when the incident ray is given, and the constant ratio of refraction which belongs to any transparent body, we may trace the progress of rays through bodies of any form whatever, provided we have the lines given which are perpendicular to the surface of the body at the points where the rays fall upon it. In all spherical surfaces this perpendicular is a line drawn through the point of incidence and the centre of the spherical surface; and in all other cases it is a line perpendicular to a line touching the surface at the point of incidence.

The names of *prisms* and *lenses* have been given to those transparent bodies which are most useful in optical experiments, and in the construction of optical instruments. Sections of these different refracting bodies are shown in the annexed diagram.

Fig. 22.

1. A *prism*, represented in the figure at A, is a solid piece of glass, having three plane surfaces, AR, AS, RS, which are called its refracting faces, the light passing through any two of them.

2. A *plane lens* (B) is a lens the centre of whose surfaces are infinitely distant. Its sides are therefore parallel like a piece of plane glass.

3. A *spherical lens* (C) is a lens whose surfaces have the same centre, and is consequently a sphere or a part of one.

4. A *double convex lens* (D) has two convex spherical surfaces, whose centres are on opposite sides of the lens. It is said to be *equally convex* when the radii of its two surfaces are equal; and *unequally convex* when the radii are unequal.

5. A *plano-convex lens* (E) is a lens which has one of its surfaces flat or *plane*, and the other *convex*.

6. A *double convex lens* (shown at F) is a solid bounded by two concave spherical surfaces. It is *equally concave* when its surfaces have the same radius, and *unequally concave* when they have different radii.

7. A *plano-convex lens* (G) has one of its surfaces concave and the other plane.

8. A *meniscus lens* (H) has one of its surfaces *concave* and the other *convex*, the two surfaces meeting if continued. The convexity predominates, and it acts as a convex lens.

9. A *concavo-convex lens* (I) differs from the meniscus only in the circumstance that the two surfaces do not meet if continued. Hence the concavity predominates, and the lens acts as a concave one.

10. A *cylindrical lens* is shown in fig. 23; it is merely a cylinder of glass, or any other transparent body.

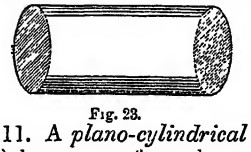
Fig. 23.

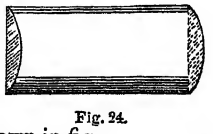
Fig. 24.

11. A *plano-cylindrical lens* (shown in fig. 24) has one surface plane and the other cylindrical.

12. A *transverse cylindrical lens* (fig. 25) resembles two plano-cylindrical lenses, plane transversely, or with their lengths at right angles to each other, and joined together by their plane surfaces at *a*, *b*, *c*, *d*.

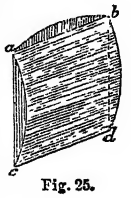

Fig. 25.

Dioptrics.

Refraction by prisms.

Refraction by Prisms.

As prisms are essential parts of optical instruments, and are of peculiar value in experiments on light, it is necessary to have a correct idea of the phenomena which they exhibit in refracting rays of light.

Let ABE (fig. 26) be a prism of two equal sides BA, BE, and made of glass whose index of refraction is 1·500, or whose ratio of refraction is as 1·500 to 1, or as 3 to 2, and let RC be a ray incident on its first surface at C. It is required to determine the path of this ray after it has suffered refraction at both its surfaces AB, BE. From any scale set off CG equal to 10 divisions, and CR equal to 15, and through G draw GD perpendicular to AC. From the point C, and on the line GD, set off CD equal to CR, and through D and C draw DCc; then Cc will be the refracted ray. From a scale on which Cc is 10, set off cCg equal to 15 parts, and drawing qd perpendicular to BE, make cd equal to cC, and draw through d and c the line dcr; then cr will be the path of the ray refracted by the second surface BE of the prism. When the radius Cc will not reach the perpendicular gd, the ray Cc will not be refracted at all, but will suffer total reflection. When total reflection commences, the point d will fall in the line EB, and the perpendicular gd will touch the circle described with the radius cC round c, at the point d. At all greater angles of incidence the ray Cc will be totally reflected.

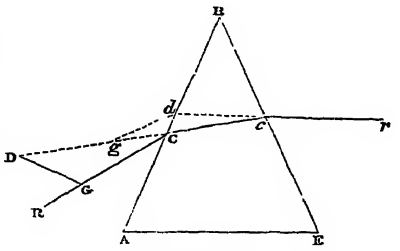

Fig. 26.

The sine of the angle of incidence at c, when the ray Cc is not able to emerge from the prism, but suffers total reflection, will be found in the case of plate-glass (whose index of refraction is 1·500) to be equal to $\frac{1}{1\cdot500}$, or $\frac{2}{3}$, or 0·666; the angle corresponding to which is 41° 48′.

The total reflection which thus takes place within transparent bodies is a very remarkable and highly interesting phenomenon. The light is far more brilliant than what is obtained from the brightest silver, which gives more reflected light than any other metal; and it possesses curious physical properties, which will be explained in a subsequent part of the article. The phenomenon of total reflection may be finely seen by filling a tumbler-glass with water, and placing it above the head, so as to see the image of a candle reflected from the lower side of its surface when at rest. The brilliancy of the image surpasses that of every other species of reflection. Diamonds, precious stones, and the glass ornaments of chandeliers, &c. &c., are often cut so as to send to the eye light that has suffered total reflection. The brilliant white lustre of dew-drops arises from totally reflected light.

To a person under perfectly still water, the vision of objects either out of the water or on the bottom must be very singular. The whole visible heavens, in place of being a hemisphere, will appear like a cone, with an angle of 97°. "All objects," says Sir John Herschel, "down to the horizon, will be visible in this space, and those near the horizon much distorted and contracted in dimensions, especially in height. Beyond the limits of this circle will be seen the bottom of the water and all subaqueous objects reflected, and as vividly depicted as by direct vision. In addition to these peculiarities, the circular space above mentioned will appear surrounded with a perpetual rainbow of faint but delicate colours." In order to understand this, let MN (fig. 27) be the surface of the water, and E an eye at the bottom. Let DE be the direction in which a horizontal ray ND would be refracted at D, and CE the direction in which MC would be refracted at C. Then it is clear that all objects on the horizon will be seen in the directions ED, EC, and as the same is true in every azimuth, ACEDB will be a section of the cone, which will comprehend within it all objects in the visible horizon. The sun and moon will appear to rise at A and set at B. They will have the appearance of ovals, with their smaller diameters vertical. They will quit the horizon, and descend to it again very slowly, as the angle of refraction varies very slowly from 90° of incidence downwards. If a man fishing near N stands up to his knees in water, his knees will just be seen above the water, in the direction EB, and his body standing within the cone BEA, while his legs will be seen bright, and inverted in the direction of about EN, by the total downward reflection of the surface MN of the water. If we draw Cc and Dd, making the angles cCE, dDE, equal to CED, then all objects in the water, to the right hand of d, and to the left hand of c, will be seen by total reflection from the inner surface MN of the water, in the space surrounding the cone AEB. An object at c will be seen by reflection from the point C in the direction EC, and an object at d by reflection from D; but none of the objects between c and d will be seen by reflection to the eye at E. Hence we see the reason why the fisherman's legs, like other objects under water, will be seen by total reflection in a direction near to EN. The circular rainbow, or rather fringe of colours, which separates the objects out of the water from those which are beneath it, and seen by total reflection, is that band of colour which always bounds light that is totally reflected.

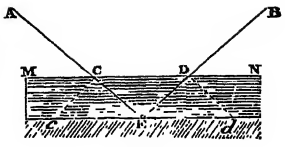

Fig. 27.

It frequently happens, both in optical experiments and in optical instruments, that light is refracted at the surfaces of two media placed in contact, such as water and glass, and in compound lenses of flint and crown glass, either touching one another or united by a cement. In all such cases, it is necessary to determine the refraction which light experiences at their refracting surface. It is found by experiment, and may be proved theoretically, that the index of refraction for the separating surfaces of media is equal to the quotient of the most refractive divided by the least refractive medium. Thus, the index of refraction for the separating surface of water and plate-glass will be $\frac{1\cdot500}{1\cdot336}$, or 1·122, which is nearly the same as that of tabasheer. In order, therefore, to find the refracted ray in this case, let MN (fig. 28) be a parallel stratum of water resting upon a piece of parallel glass OP. A ray RC will be refracted in the direction Cc', and may be found by the method formerly given. In order to find the change produced in the direction of the ray at c', take a point g', in the line c'C, so that if c'C is 1·122, $c'g'$ shall be 1·000, then drawing $g'd'$ perpendicular to the refracting surface, make $c'd'$ equal to c'C; and having drawn through the points d, c' the line $dc'c$,—$c'c$ will be the refracted ray. This ray being incident on the second surface of the glass plate at c, will be refracted in a direction cr, which may be found by the method formerly described. It will be found both by projection and by experiment,—namely, by looking through the compound plate MNOP, and observing any distant object,—that the finally refracted ray cr is parallel to the incident ray RC.

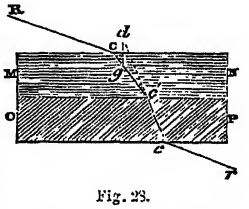

Fig. 28.

If the angle RCA (fig. 26), the complement of the angle

Dioptrics. of incidence, is increased, the point c, where the refracted ray emerges from the side BE of the prism, will approach to E, and the angle rcE will diminish, till at a particular inclination of the incident ray the angle RCA will become equal to the angle rcE. When this happens, the refracted ray Cc, will be equally inclined to the refracting faces of the prism BA, BE, and will be parallel to the base AE. This will be obvious by considering Cc as an internal ray incident on both sides of the prism, and at equal angles to each, in which case it will suffer equal degrees of refraction, and therefore be equally inclined to the refracting faces.

If the eye is placed at r to receive the refracted ray cr, it will see the luminous body, such as a candle, from which the ray RC proceeds, in the direction rc, and the angle which this ray rc forms with RC will be the deviation of the ray produced by the refraction of the prism. Let us now suppose the candle to be fixed, and the prism turned round, so that the angle RCA may be increased; it will be found experimentally, and may be easily proved by projection, that the deviation of the ray rc is *least* when the angle RCA is equal to rcE, or when Cc is parallel to AE, and increases when Cc deviates on either side from this mean position. Now this position may be easily ascertained by placing the eye behind the face BE, and turning the prism till the refracted image of the candle, or other object, becomes stationary. When this takes place, Cc is parallel to AE, or CcB is an isosceles triangle; and it may easily be shown, by similarity of triangles, or by projection, that *the angle of refraction at the first surface is equal to half the angle of the prism, or* $\frac{1}{2}$ABE. Hence we obtain the following simple rule for finding the index of refraction, after having measured, with a goniometer or otherwise, the angle of incidence, or the complement of the angle RCA:—Divide the sine of the angle of incidence by the sine of half the angle of the prism, and the quotient will be the index of refraction.

For the purpose of measuring indices of refraction, we do not require regular prisms of considerable size. Two small faces, well ground and tolerably polished, are sufficient for this purpose. They need never be larger than the pupil of the eye, and will answer well enough if they are of the size of a pin's head. If we wish to measure the index of refraction of fluids, we have only to place a drop of the fluid at the angular point A of two pieces of parallel glass AB,AE (fig. 29), fixed at any angle by a piece of wood or wax BE. Enough of the fluid for the purpose will be retained by capillary attraction at the point A, and after measuring the angle BAE of the prism, and the angle of incidence at which the image of the candle becomes stationary, the index of refraction will be found as before.

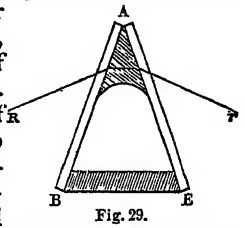

Fig. 29.

Refraction through Plane Glasses.

Refraction by plane glasses. Every person is acquainted with the fact that light which passes through plane glasses, or glasses which have their two surfaces flat and parallel, like MN in fig. 30, does not suffer any very perceptible change, either in its general direction, or in the parallelism, convergency, or divergency of its rays. If AB, A′B′, for example, be two parallel rays incident on the plate of glass MN, they will suffer equal refractions at B, B′, because they are incident at the same angles, and the refracted rays BC, B′C′ will therefore be parallel. These parallel rays again falling upon the second surface at C, C′ will suffer equal refractions there, and will emerge parallel in the lines CD, C′D′. Dioptrics.

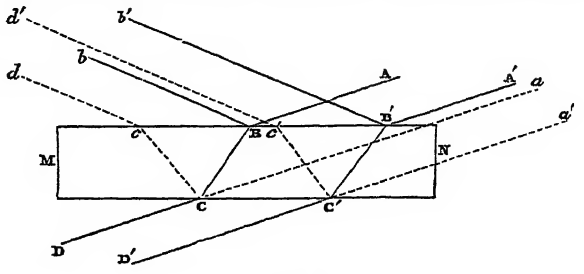

Fig. 30.

Hence we conclude that parallel rays after transmission, at any obliquity, through a plane glass, will emerge parallel. But as the rays DC, D′C′ will, to an eye at D and D′, be seen in the directions DCa, D′C′a', their absolute directions in space are altered, and the difference between the real and the visible direction will increase with the obliquity of the rays AB, A′B′, and with the thickness of the plate of glass. If we suppose MN to be part of a looking-glass, silvered on its lower side CC′, then the refracted rays BC, B′C′ will, after reflection at C, C′, in the directions Cc, C′c', be refracted at c, c' into the parallel directions cd, $c'd'$. But the rays AB, A′B′ will be reflected, though in a much fainter degree, in the directions Bb, B′b'; so that an eye placed so as to receive these rays will see the bright image reflected from the silvered surface, in the direction cd, and the faint image reflected from the first surface, in the direction Bd, at a distance from each other depending on the obliquity of the reflection, and on the thickness of the plate. A candle, for example, will be seen double at a short distance from the mirror; but a larger object, in order to be seen double, must be viewed at a greater distance. At great obliquities, and when the objects are very luminous, such as gas-burners, &c., other images will be seen by reflections at c, c', and the subsequent reflections from the other side of the plate. If the two faces of the plate are not exactly parallel, the bright and faint images above described will change their distance, sometimes overlapping each other, and sometimes separating, according to the part of the plate on which they fall, though the angle of incidence may remain the same.[1]

When *diverging* and *converging* rays pass through a plane glass, the position of the points of divergency and convergency are altered. Let ABB′ (fig. 31) be a pencil of rays diverging from A, and incident upon the plane glass MN. The emergent rays CD, C′D′ will, after the second refraction at C, C′, proceed as if they had come from the point b. Hence a plane glass brings the divergent point of diverging rays nearer to it. For the same reason, if DbD′ is a converging beam of light, its point of convergency b, will be removed to A by the plane glass.

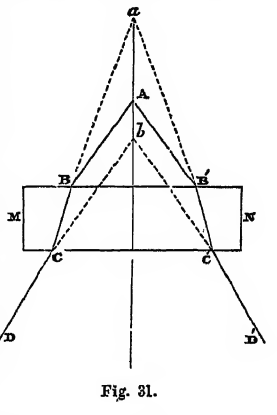

Fig. 31.

When there is only one refraction, as in the case of standing water, whose surface is BB′, and bottom CC′, then the very reverse will be the result. A diverging beam ABB′ will have its divergent point removed to a, and a converging beam would have it brought nearer the surface.

[1] We had once a looking-glass of this kind sent to us as a curiosity by a gentleman, who valued it on account of its remarkable properties. It differed from all the rest in his possession only in its being the worst.

Dioptrics.

Refraction of Rays by Spheres.

Refraction by spheres.

When a ray of light falls upon a curved surface of any kind, the infinitely small part of the surface which it occupies may be considered as coinciding with the tangent to the surface, or with a plane surface touching the curve at the point of incidence. When the surface is spherical, this tangent plane is perpendicular to the radius, or the line drawn from the centre of the sphere to the point of incidence. Hence it is always given when the centre is given.

Let *MN* (fig. 32) be the section of a sphere of glass, whose index of refraction is 1·500, as before; RS*f* a ray passing through its centre S, and therefore unrefracted, because it is incident perpendicularly on both surfaces; and

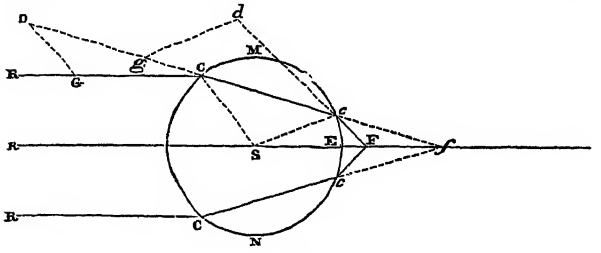

Fig. 32.

RC, RC other rays parallel to, and equidistant from, RS*f*; it is required to find the path of one of these, RC, through the sphere. Join SC, which will be perpendicular to the surface at C. From a scale on which RC is three parts, set off RG equal to 1, and draw GD parallel to CS (which is the same as drawing it perpendicular to the elementary surface, or tangent to the sphere at C). Make CD equal to CR, and through D and C draw the line D*Cf*, meeting the posterior surface of the sphere at *c*, and the axis of the sphere at *f*. The point *f* would have been the focus, had there been no second surface to refract the ray C*c* a second time. On a scale on which C*c* is two parts, set off C*g* equal to 1 part, and having joined S*c*, draw *gd* parallel to S*c*, and make *cd* equal to *c*C. Through *c* draw *dc*F, meeting the axis of the sphere in F. As the ray RC, below RS*f*, falls in the very same manner on the sphere MN, it will have its refracted ray in a similar direction, and the two rays will meet at F, which is called the focus of the sphere for parallel rays, or the principal focus of the sphere.

If we determine the path of the ray RC, and find the foci *f* and F for both surfaces; by using different indices of refraction, we shall find that in every case the distance EF of the principal focus of the sphere is exactly one-half of the distance E*f* of the focus for the first surface, and that FS is to ES as the sine of incidence or the index of refraction is to the difference between twice the sine of incidence and twice the sine of refraction; that is, in glass, as 1·500 is to 3·000 − 2·000, or as 1·500 to 1·000.

Hence we have for different refractive bodies the following results:—

	Index of Refraction.
Tabasheer	FS is to ES as 1·111 is to 0·222
Water	FS is to ES as 1·336 is to 0·672
Glass	FS is to ES as 1·500 is to 1·000
Zircon	FS is to ES as 2·000 is to 2·000

Hence it appears that in the case of zircon, and all other bodies whose index of refraction is 2·00, the focus F falls exactly on the posterior surface of the sphere at E; and it therefore follows that in diamond, phosphorus, &c., and all bodies whose refractive power exceeds 2·000, the principal focus falls *within the sphere*, the focus advancing from E towards S, as the index of refraction increases, and reaching the centre of the sphere S, when the index of refraction becomes infinite.

It may be interesting to trace the distances E of the principal focus F from the sphere, in bodies of various refractive powers, supposing the radius of sphere to be 1 inch, and placed *in vacuo*. Dioptrics.

	Distances EF.	Ft.	in.	
Hydrogen	3623 inches	301	11	
Oxygen	1838 „	153	2	
Atmospheric air	1701 „	141	9	
Phosgen	432 „	33	0	
Tabasheer	4 „	0	4	
Water	0·98 „	0	1	nearly.
Glass	0·50 „	0	0½	
Zircon	0·00 „	0	0	
Diamond	within the sphere.			

In spheres of diamond, and other substances of high refractive power, a refracted ray C*c* may fall so obliquely upon the inner surface of the sphere, that it would be totally reflected, and would therefore be carried round the surface of the sphere, without the possibility of making its exit. If the length of the refracted ray C*c* should cut off an arc which is an aliquot part of a circle, the ray would describe a regular polygon, being always reflected from the same points; but if it was not an aliquot part of a circle, the points of reflection would vary in every revolution of the ray.

The following is the rule for finding the principal focus of a sphere, or its focus for parallel rays:—Divide the index of refraction by twice its excess above unity, and the quotient is the distance of the principal focus from the centre of the sphere.

When the rays RC, RC, in place of falling on the sphere in directions parallel to the axis, or to one another, proceed from a near object, and always from a point in the axis RSE, their focus may be found by the very same method which we have already given. When the point from which the rays diverge is very distant, the focus of such rays will be a little farther from the sphere than F, and as the radiant point approaches to the sphere, the focus F will recede from it, as will be more fully explained when we treat of the progress of rays through lenses.

Refraction of Rays by Convex Lenses.

Refraction by convex lenses.

The action of an equally convex lens in refracting the rays of light, is exactly the same as that of a sphere, with this difference only, that the two surfaces are brought nearer each other, and in consequence of this, the ray refracted by the first surface falls upon the second surface at a different point, and at a different angle, the effect of which is to produce a change in the position of the focus.

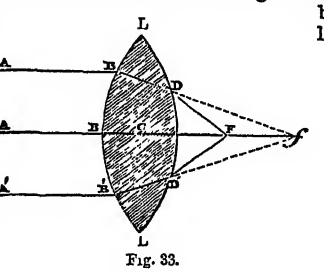

Fig. 33.

Parallel rays.

If LL (fig. 33) be a double and equally convex lens of glass, a line A*f* passing through the centre C, or middle point of its greatest thickness, is called its *axis*. Let *parallel rays* AB, A′B′ fall upon the first surface at the points B,B′; these will be refracted in directions BD, B′D′, which will be determined by the method shown in fig. 32. Had there been no second surface, these rays would have converged to a focus at *f*, but as they meet the second surface of the lens at D and D′, they will there be refracted, as shown in fig. 32 for the sphere, so as to take the directions DF, D′F, and have their principal focus at F.

The following is the rule for finding the principal focus of a glass lens unequally convex:—Multiply the radius of the one surface by the radius of the other, and divide twice this product by the sum of the same radii.

If the glass lens is equally convex, and has its index of refraction 1·500, the distance CF, or its principal focal distance, will be equal to the radius of any of its surfaces.

The following is the rule for finding the principal focal

Dioptrics.

distance of a plano-convex lens of glass. When the convex side is exposed to parallel rays, the focal distance, reckoned from the plane side, will be equal to double the radius of the convex surface, diminished by two-thirds of the thickness of the lens. When the plane side of the lens is exposed to parallel rays, the distance of the focus from the convex side will be equal to twice the radius.

Oblique rays.

When the rays AB, A′B′, A″B″ (fig. 34) are oblique to the axis, the middle ray ABC, passing through the centre C, will obviously suffer refraction at B, but as it falls upon the second surface at the same angle, it will be refracted a second time in an opposite direction, so that it will proceed in a direction *df* parallel to AB. The rays A′B′, A″B″ will suffer refraction at the points B′, B″, and also at the points D, and D′, and it will be found by projection that they meet in a focus F in the axis *df*.

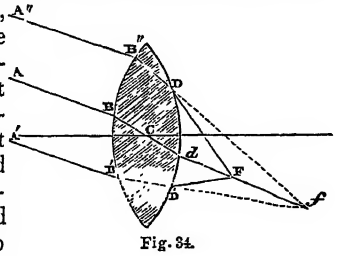

Fig. 34.

Diverging rays.

In the preceding case the parallel rays are supposed to issue from some very distant object; but if the object from which the rays proceed is near or not very distant from the lens, its focus will recede from the lens, in proportion as the object or point of divergence approaches to it. This fact scarcely requires to be proved, for it is manifest that as the radiant point approaches to the lens, the rays fall more and more obliquely on the first surface, and less and less obliquely on the second, so that the deviation produced by refraction is not sufficient to bring them to a focus so near the lens as the point F, in fig. 33. This will be better understood from fig. 35, where LL is a convex lens, whose focus for parallel rays is F. Let RL, RL be rays diverging from a candle or other body, at R, then, if we trace the refracted rays by the method already given in fig. 32, we shall find that they will meet at a point *f*, farther from the lens than F, and that if the point R advance to R′, the focus *f* will advance to *f*′, and so on, the focus *f*′ receding from the lens as R approaches to it. When the distance RC is equal to twice CF, or twice the principal focal distance, the distance of the focus *f*′ from the lens will be equal to the distance of radiant point from it, or C*f*′ will be equal to CR′. When R comes nearer C, *f*′ goes rapidly away from it, and when R comes to F′, which is called the anterior focus, CF′ being equal to CF, the rays will be parallel, or what is the same thing, the focus *f* will have retired to an infinite distance. When R comes nearer to C than F′, the rays will diverge, after passing through the lens, as if they came from some point in front of the lens, and this point, or *virtual focus*, as it is called, will approach to the lens as R approaches it, in moving from F′ towards C. The points R and *f* and R′ and *f*′, are called *conjugate foci*, because it may be shown that rays diverging from *f* will be refracted to R, and rays diverging from *f*′, to R′. It is indeed a general truth in all the phenomena of refraction and reflection, that if the refracted rays are supposed to be the incident ones, the incident rays will be the refracted ones; for the ray experiences the very same action in an inverse order, by retracing its path.

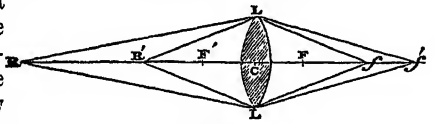

Fig. 35.

The following is the rule for finding the focus *f*, or the conjugate focal length of a convex lens of glass for diverging rays:—Multiply twice the product of the radii of the two surfaces of the lens, by the distance of the radiant point or RC, for a *dividend.* Multiply the sum of the two radii by the same distance RC, and from this product subtract twice the product of the radii, for a *divisor.* The quotient of the dividend divided by the divisor will be the focal distance C*f* required.

Dioptrics.

When the lens is *equally-convex*, multiply the distance of the radiant point RC by the radius of the surfaces, and divide that product by the difference between the same distance and the radius, and the quotient will be the focal distance C*f* required.

If the lens is *plano-convex*, divide twice the product of the distance of the radiant point RC multiplied by the radius of the convex surface, by the difference between that distance and twice the radius, and the quotient will be the distance of the focus from the centre of the lens.

Converging rays.

When converging rays fall upon a convex lens, they are always refracted to a point between the lens and their point of convergence. Let RL, RL (fig. 36) be rays converging to any point *r*, behind the lens LL, it is very evident that refraction must always make them cross the axis RC*r* of the lens somewhere between *r* and the lens, and always between the principal focus F and the lens. The exact point may be found by the methods already given. As the point of convergence *r* recedes from the lens, the focus *f* will approach to the principal focus F, and when *r* is infinitely distant, the rays RL, RL become parallel, and *f* will coincide with F. When *r* approaches to C, *f* will also approach to it.

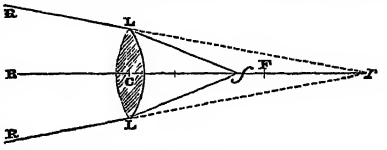

Fig. 36.

The focus of a *double-convex* glass lens, when its thickness is small, for converging rays, may be found by the following rule:—Multiply twice the product of the radii of the two surfaces by the distance *r*C of the point of convergence, for a *dividend.* Multiply the sum of the two radii by the same distance *r*C, and add to this product twice the product of the radii, for a *divisor.* The quotient obtained by dividing the above dividend by this divisor, will be the focal distance *f*C required.

When the lens is *equally-convex*, multiply the distance *r*C by the radius of the surfaces, and divide that product by the sum of the same distance and the radius, and the quotient will give the focal distance *f*C required.

In *plano-convex* lenses we must divide twice the product of the distance *r*C multiplied by the radius of the convex surface, by the sum of that distance and twice the radius, and the quotient will give the focal distance required.

Refraction of Rays by Concave Glasses.

Refraction by concave lenses.

In order to show how to find the refracted ray when the light is incident on a *concave* surface, let LL (fig. 37) be a double and equally concave lens of glass, and RB, R′B′ two rays parallel and equidistant from the axis RC of the lens. From a scale on which RB is 1·5, take BG equal to 1, and from G draw GD parallel to SB, the radius, and consequently perpendicular to the first concave surface of the lens. Make BD equal to BR, and through D and B draw DB*b*, which will be the ray refracted by the first surface. On a scale where *b*B is 1, make *b*B*g* equal to 1·5. From *g* draw *gd* parallel to *bs*, the radius of the second surface, and consequently perpendicular to that surface at *b*. Make *bd* equal to *b*B, and through *b* draw *dbr*; *br* will be the ray refracted by the second surface. In like manner, the other ray R′B′ will be refracted

Parallel rays.

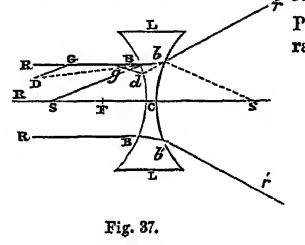

Fig. 37.

Dioptrics. by the first surface, in the direction B′*b*′, and the two refracted rays *br*, *b*′*r*′ will diverge as if they had proceeded from a point F, found by continuing *br*, *b*′*r*′ backwards, which is called the virtual focus of the concave lens LL.

If we trace *oblique parallel* rays through a double concave lens in the same manner as we have done for a convex one in fig. 34, we shall find that they will be refracted as if they diverged from a focus in the axis or ray which passes through the centre of the lens. The rules for finding the virtual focus of parallel rays refracted by a double-concave or plano-concave lens, are the same as for convex lenses.

Diverging rays. When *diverging* rays RB, RB (fig. 38) fall upon a concave lens LL, they will be refracted in lines *br*, *b*′*r*′, more divergent than parallel rays, as if they proceeded from a virtual focus *f*, nearer the lens than its principal focus F. As the radiant point R approaches to C, *f* will approach to C.

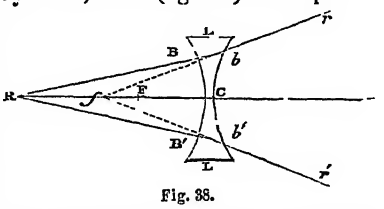

Fig. 38.

The following are the rules for finding the virtual focus of a concave lens of glass for diverging rays:—Multiply twice the product of the radii by the distance RC of the radiant point R, for a *dividend*. Multiply the sum of the radii by the distance RC, and add to this twice the product of the radii, for a *divisor*. Divide the dividend by the divisor, and the quotient will be the virtual conjugate focal distance *f*C. If the lens is *equally-concave*, multiply the distance of the radiant point R by the radius, and divide the product by the sum of the same distance and the radius, and the quotient will be the virtual focal distance required.

If the lens is a *plano-concave* one, multiply twice the radius by the distance of the radiant point, and divide this product by the sum of the same distance and twice the radius, and the quotient will be the virtual focal distance.

Converging rays. When *converging rays* fall upon a concave lens, their virtual focus will be without the principal focus on one side, if the point of convergence is without the principal focus on the other side. This case is shown in fig. 39, where the rays RB, R′B′, converging to *f*, without the principal focus F, will be refracted in the direction B*r*, B′*r*′, as if they had diverged from a focus at *f*′ on the other side of the lens. When *f*C is equal to twice the principal focal distance CF, the virtual focus of divergence *f*′ will be at the same distance on the left hand of C as the point of convergence *f* is distant on the right hand. When *f* approaches the lens on the right hand, the virtual focus *f*′ will recede from it on the left. When *f* reaches F, the virtual focus will be infinitely distant, or the refracted rays will be parallel; and when *f* advances from F to the lens, the refracted rays will converge on the right hand of the lens, and the focus will advance towards the lens, as the point of convergence advances towards it.

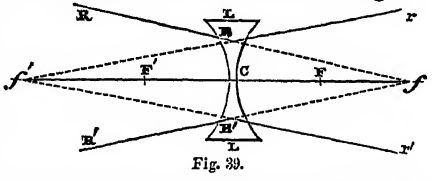

Fig. 39.

The rule for finding the conjugate focus of a converging beam, for a doubly concave lens, is the same as that for diverging rays in a doubly convex lens. If the lens is plano-concave, the rule is the same as for diverging rays falling upon a plano-convex lens.

Refraction of Rays by Meniscuses, and Concavo-Convex Lenses.

It would be quite unprofitable to trace the progress of different rays through these various forms of glasses, both because they are but little used, and because the very same methods which are applicable to convex and concave surfaces, are applicable also to them. When used by themselves and for ordinary purposes, these lenses are inferior to the common convex and concave lenses, and therefore are seldom met with. We shall therefore content ourselves with giving the rules for finding their foci. Dioptrics. Refraction by meniscuses,

In a meniscus the focus for parallel rays is obtained by dividing twice the product of the two radii by their difference, and the quotient will give the focal distance.

In the same kind of lens the focus for diverging rays will be thus found:—Multiply twice the distance of the radiant point by the product of the radii of the two surfaces, for a *dividend*. Multiply the same distance by the difference between the two radii, and to their product add twice the product of the two radii, for a *divisor*. The quotient arising from dividing the dividend by the divisor, will be the focal distance of the meniscus. This rule will answer also for converging rays.

In *concavo-convex* lenses the very same rules will apply, but the rays have a virtual focus in front of the lens, as in concave lenses. and concavo-convex lenses.

In treating of the passage of oblique rays through a double convex glass (as shown in fig. 34), we have stated that there is a point C, called the centre of the lens, through which the ray that passes suffers the same refraction at both surfaces, or emerges parallel to its original direction. In equi-convex lenses, this centre C is accurately in the middle line of the thickness of the lens; but in other forms of lenses it is not. Hence it is necessary to point out the method of finding this centre. In *double convex* or *concave lenses*, the centre C (see figs. 34, 40, and 41) lies within the two surfaces of the lens. In *plano-convex* and *plano-concave* lenses, it is coincident with the vertex of the convex or concave surfaces, and in *meniscuses* and *concave-convex lenses* it lies without the thickness of the lens, and nearest to the surface which has the greatest curvature. Let R, *r* (figs. 40–43) be the centres of the convex and concave surfaces of the lenses, and RE*r* (figs. 40, 41), or R*r*E (figs. 42, 43), are their axes. Taking any point A in one surface, draw RA, and parallel to this draw *ra*, which will cut the other surface of the lens in *a*. Join A*a*, and continue it till it meets the axis RE*r* or R*r*E in some point E; this point E is called the centre of the lens, because every ray that passes through it will have its incident and emergent parts parallel, such as QA and *qa*. From the similarity of the triangles REA, *r*E*a*, and the composition and division of ratios, we have RA∓*ra* : *ra* = RE∓*r*E (or R*r*) : *r*E. Hence *r*E must be invariable like the other lines, and on whatever point the parallel radii RA, *ra*, are drawn, the line A*a* must cut the

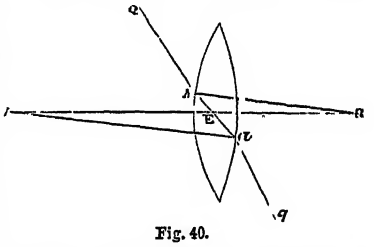

Fig. 40.

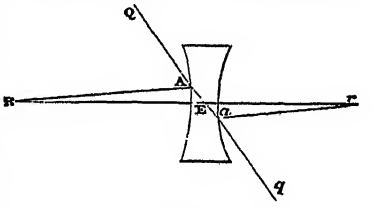

Fig. 41

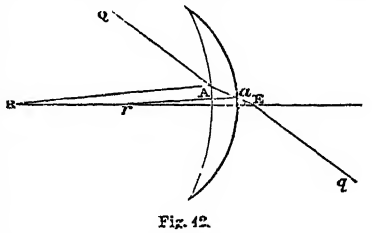

Fig. 42.

Dioptrics.

axis R*r* in the same point E. If we suppose the ray A*a* to pass out of the lens in both directions, it will suffer the same quantity of refraction in opposite directions, because the angles of incidence *a*AR, E*ar*, are equal. Hence the incident and emergent parts, AQ, *aq*, will be parallel.

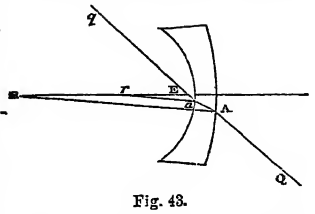

Fig. 43.

When the lens is small in diameter, or of a great focal length, or its thickness inconsiderable from other causes, the path of the ray Q*Aaq*, may be taken as a straight line passing through the centre E of the lenses. This is evident from the circumstance that the perpendicular distance between the lines AQ, *aq* diminishes both with the obliquity of the incident ray and the thickness of the lens.

On the Refraction of Rays by Cylindrical Lenses.

Refraction by cylindrical lenses.

Cylindrical lenses may have all the forms of the lenses which we have already described. A perfect cylindrical lens corresponds with a sphere whose section is the same; a plano-convex cylinder has its section similar to a plano-convex lens of the same dimensions; and a meniscus cylinder has one of the cylindrical surfaces convex and another concave.

In all these cases the curved surfaces are cylindrical; that is, circular in one direction, and rectilineal in another; but we may combine a spherical surface either convex or concave, with a cylindrical surface either convex or concave, and thus produce cylindro-spherical lenses, an ingenious application of which to vision was made by Mr Airy, for the purpose of remedying a defect in his own eye.

This class of lenses, therefore, whether entirely cylindrical or cylindro-spherical, having been found of real use both in matters of science and for the purposes of vision, it becomes of consequence to give a general account of their properties.

Let LLL'L' (fig. 44) be a double convex cylindrical lens, composed of two cylindrical surfaces, one of which is LLL'L' Then if RRR be three parallel and horizontal rays passing through the thinnest portion of the upper part of the lens, it is obvious that they will be refracted to a focus at F, at the same distance from the lens as in an ordinary lens.

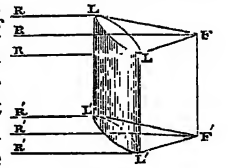

Fig. 44.

In like manner the rays R'R'R' falling upon the lowest portion of the lens will have their focus at F'. Every intermediate portion of the lens will have a similar focus somewhere in the line FF', and if we suppose all the rays to proceed from a distant object, such as the sun, there will be an image of the sun, or a luminous focus in every point of the line FF', and FF' will be a brilliant line of light.

This property of a cylindrical lens to form a bright line of light has been ingeniously applied by Captain Kater in the construction of his azimuth compass, which we have described in our article Magnetism, vol. xiv.

In cylindrical lenses diverging and converging rays will have the same foci as in common and concave lenses of the same curvature; and therefore the rules for finding their foci are applicable also to them.

Cylindrical lenses have been applied by Sir David Brewster for improving the vision of objects that are rectilineal, such as the defective lines in the solar spectrum. When these lines are not visible, or are very imperfectly visible, on account of the imperfections of the telescope, the application of a cylindrical lens, either solid or fluid, renders them more visible when the axis of the cylinder or cylindrical surface is accurately perpendicular to the lines. A prism has a similar effect. Both of them act in filling up the irregularities of the edges of the lines by a succession of images of other parts of the line. If we look, for example, at a screw nail, or a twisted or rough rope, through a prism or cylinder, whose length is perpendicular to the screw or rope, the edges of both will be as smooth as if they were polished cylinders. Dioptrics.

A patent was taken out several years ago by a Parisian artist for a transverse cylindrical lens similar to that shown in fig. 25; which differs from the cylindrical lens in fig. 42 in this, that the second cylindrical surface has the axis of the cylinder of which it is a part, perpendicular to the axis of the cylinder of which the first surface is a part. The effect of this combination is *exactly* equivalent to a plano-convex glass of the same radii of curvature, and therefore it does not possess any superior properties, as was believed by its inventor.

If we cross two cylindrical lenses, such as that in fig. 41, at right angles, we shall have all the effect of a double convex lens. Or if we cross two good test tubes filled with water or any other fluid, in the same manner, we shall also obtain a rude imitation of the effect of a spherical lens, which may answer for the common purposes of a microscope. (See Microscope, vol. xiv.)

Mr Airy's sphero-cylindrical spectacles.

The application of a cylindro-spherical lens by Mr Airy to the purpose of remedying imperfect vision in his own eye, deserves to be more particularly noticed. He found that his eye refracted rays to a nearer or shorter focus in a vertical than in a horizontal plane,[1] so that his eye was completely useless. Hence he concluded that the curvature of his cornea was greater in a vertical than in a horizontal plane, and he ingeniously proposed to correct this defect by cylindrical refraction. As the eye was short-sighted, he required concave surfaces to correct the general defect of a too convex cornea. He therefore had a lens constructed which was doubly concave, one of the surfaces being spherically concave, and the other cylindrically concave, and of such a curvature as to bring to the same point the vertical and horizontal foci of the cornea. An artist of the name of Fuller, at Ipswich, constructed for Mr Airy lenses of the proper dimensions, which enabled him to read the smallest print at a considerable distance with his defective eye, as well as he could do with the other. He found that vision was most distinct when the cylindrical surface was turned from the eye, and he placed the lens as near the eye as possible. There is another application of cylindrical lenses which we believe has not hitherto been made. In all preparations of natural history, objects which are generally preserved in cylindrical bottles or vessels containing fluids, the objects are always seen distorted, being magnified to the greatest extent in a plane perpendicular to the length or axis of the cylinder, while in a rectangular direction the object is not magnified at all. In order to see the objects of their true shape, and have them equally magnified in all directions, a cylindrical lens of a suitable focus should be employed, so that the axis of the cylinder may be at right angles to the cylindrical axis of the vessel.

Sect. III.—On the Formation of Images by Lenses, and on the Vision of Objects through them.

In the preceding section we have treated of the formation of images by rays transmitted through small apertures, and have considered the formation of images by reflecting surfaces.

In order to explain the formation of images by convex lenses, whether double, or plano-convex, or meniscuses, let

[1] This was the case also in Dr Thomas Young's eye, but it did not injure his vision. (*El. Nat. Phil.*, vol. ii., pp. 578, 579.)

Dioptrics. LL (fig. 45) be a convex lens, MN an object farther from it than its principal focus. Let MLL be a cone of divergent rays proceeding from M, and having their focus at *m* behind the lens; and NLL another similar cone from the other extremity N of the object, and having their focus at *n*. Every other part of the object will send out rays in all direc- Dioptrics.

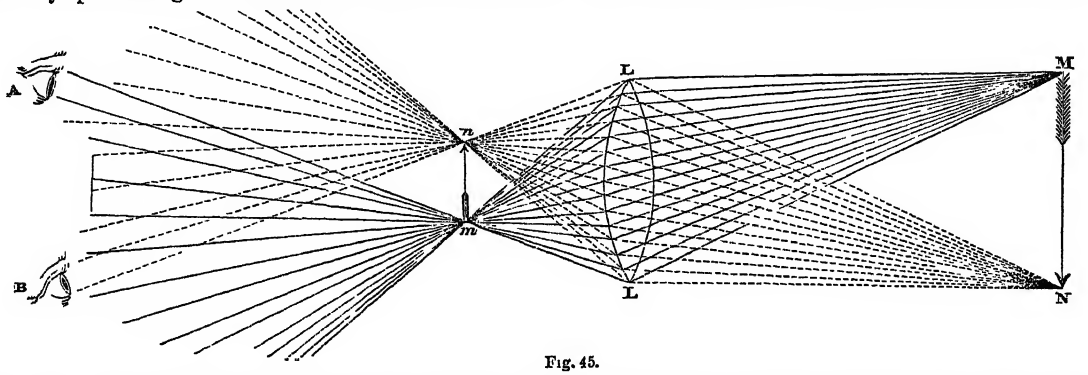

Fig. 45.

tions; but only those which fall upon the circular surface of the lens LL will be refracted by it, and they will all have their focus between *m* and *n*. These refracted pencils, however, cannot be shown in the figure without crossing one another. As every part of the object MN will therefore send to corresponding points of the image *mn* rays of their own colour, an image of MN resembling it in all respects will be formed at *mn*, and as the rays from the upper part M of the object go to *m*, and from the lower part to *n*, this image will be an inverted one; and if we draw lines through the centre of the lens from M to *m*, and N to *n*, it will be evident from the similarity of triangles that the size of the image will be to the size of the object as the distance of the image from the lens is to the distance of the object.

If we place the eye behind this image *mn*, we do not see it suspended in the air at *mn*, but it appears as if it were in front of the lens. That the image, however, is formed at *mn* may be proved by viewing it on smoke raised at that place, or on a piece of ground glass, or semi-transparent paper; or if we bring the eye in front, we shall see it distinctly painted on any white ground, such as a piece of white paper. We shall suppose it, however, to be seen on smoke by the eye placed behind it at A or B. It will be seen exactly at *mn* as if it were a real object; and in order to see it distinctly, the eye must view it at the same distance as it views other objects, and it may be viewed as any other object is, through a pair of spectacles or a magnifying-glass.

As all the rays from MN cross each other at the points *m*, *n* of the image, the very same rays radiate from those points that radiated from M, N, and consequently the very same effect must be produced in the eye as if these rays proceeded from a real object at *mn*. Hence, by placing another convex lens at a proper distance behind *mn*, a distance greater than its principal focus, we may form another image of this image in the conjugate focus of the second lens.

If we wish to form a magnified image of an object by any lens, we have only to place the object nearer the lens, and it follows from the rules for conjugate foci that the image will increase. If MN, for example, is brought nearer LL, the image *mn* will recede from the lens, and increase in size. When ML is equal to twice the principal focal distance of the lens, the distance of the image *m*L, and the size of the image will be the same as that of the object MN. If MN comes still nearer the lens, *mn* will recede still farther, and continue to increase in size till it becomes infinitely large and infinitely distant. When this happens, the rays which form it will have become parallel. If during all these changes the eye is withdrawn from the lens, so as to be at least six inches behind the place where the image is formed, it will observe the image distinctly before it. But when the rays become parallel, the eye may then be placed immediately behind the lens, and it will see the object distinctly in the anterior principal focus of the lens, and magnified in proportion to the shortness of the focal distance of the lens.

In the preceding paragraphs, we have described the principles of the *camera obscura*, the *compound microscope*, and the operation of the *single microscope*. When the image *mn* is distinctly formed on paper, the lens LL acts as in the *camera obscura*, painting all objects before it in their natural colours, in their just proportions, and with all their movements, on a white ground placed behind it. When the image *mn* has become greater than the object MN, by the advance of the latter to the lens, the eye views this magnified picture, and the effect is the same as in the *compound microscope*, whose object-glass is LL, and whose eye-glass has a focal distance equal to that of the eye. When the image is infinitely distant, and the rays enter the eye parallel, the object being then in the anterior principal focus of the lens LL, and the eye behind it, the lens is then acting as a *single microscope*.

When objects are within our reach, such as microscopic objects, or near objects presented before a camera obscura, it is always in our power to illuminate them with artificial light, and thus make dark objects give brighter images; but when this cannot be done, in consequence of the objects being out of our reach, we can increase the brightness of the image by increasing the area or superficies of the lens. If the area of the lens LL, for example, were doubled, it would collect twice the quantity of rays that flow from every point of an object, and concentrate them at the corresponding points of the image *mn*.

In order to understand the principle of the *telescope* and *single microscope*, we must be acquainted with what is called the *apparent magnitudes* of objects. If we hold a sixpence A (fig. 46) at the distance of six or eight inches from the eye E, then it it will exactly cover or appear equal to a shilling placed at B, a half-crown placed at C, and a crown at D. If we remove the sixpence A, the shilling will just cover the half-crown. If we remove the shilling, the half-crown will just cover the crown. Hence all these coins, placed as they are in the figure, are said to have, to an eye placed at E, the same apparent magnitude, because they are all seen under the same angle DEF, and would all cover the same portion of the sky, or of any distant object.

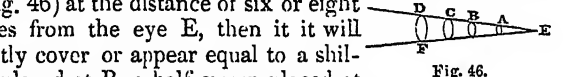

Fig. 46.

If the sixpence A is brought thrice as near the eye E as in fig. 47, its angle of apparent magnitude will now be GEF thrice as great as DEF (fig. 46), and it will appear thrice as large as DF. The sixpence has therefore been magnified; and if we interpose a lens between it and the eye, so as to make the rays refracted by the lens parallel,

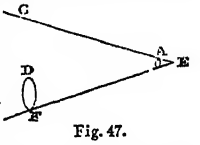

Fig. 47.

Dioptrics. it will appear distinctly *magnified*, and the lens which we interpose will be a single microscope.

Objects within our reach, and capable of being placed where we please, may be therefore magnified to any extent by placing them very near the eye, and in the anterior focus of a small convex glass, which, by making the diverging rays parallel, render the object as distinctly seen under a great angle as if it were a large object placed at a distance, and subtending the same angle at the eye.

Rationale of the telescope. But when objects are at a distance and beyond our reach, such as remote terrestrial objects, and the planets and stars, we can magnify them, or represent them to our eye under a greater angle of apparent magnitude, by a different principle. If, when the object is the dial-plate of a clock, at the distance of 12,000 feet, we place a lens whose focal distance is *six* feet in the end of a tube about 6 feet long, and direct it to the dial-plate, a distinct inverted image of the dial-plate will be formed in the focus of the lens at a distance of 6 feet from it. If we then view this image with our eye placed six inches behind it, we shall see the image of the dial-plate distinct and magnified. Now, as the distance of the dial-plate is 12,000 feet, and that of the image only *six* feet from the lens, the image will be $\frac{12,000}{6}$, or 2000 times smaller in diameter than the object, not in apparent magnitude, but by real measurement; and if we were to take the image and place it beside the dial-plate, and view them both at the distance of 12,000 feet, their apparent magnitudes would, like their real magnitudes, be in the proportion of 2000 to 1. But the image is fortunately within our reach, and we can do with it what we choose. Let us first view it with the naked eye, which, generally speaking, sees objects most distinctly at a distance of 6 inches, and as we see it at the distance of 6 inches, it will appear as much greater as it would have done at the distance of 12,000 feet as 12,000 feet is to 6 inches, or as 24,000 is to 1. Hence it follows, that though the image is diminished in the focus of the lens 2000 times, yet it is magnified from its proximity to the eye 24,000 times,—that is, it is magnified on the whole $\frac{24,000}{2000}$, or *twelve* times. Now, this magnifying effect will be found under all circumstances to be equal to the focal length of the lens employed, divided by the focal distance of the eye, or the distance at which it sees small objects most distinctly, which is 6 inches,—that is, in the present case $\frac{6 \text{ feet}}{6 \text{ inches}}$, or $\frac{72 \text{ inches}}{6 \text{ inches}}$, or *twelve* times. A short-sighted person, whose eyes have a focus of only 3 inches, would be liable to see the same image of the dial-plate at the distance of *three* inches, and in his case the magnified effect would be $\frac{72 \text{ inches,}}{3 \text{ inches,}}$ or 24 times; and an old person, or one whose eyes were long-sighted, so as not to be able to see objects distinctly nearer than 12 inches, would see the dial-plate magnified only 6 times. But both these persons could put on highly magnifying spectacles, so as to see the image at very short distances, or what is the same thing, to look at the image of the dial-plate through a magnifying glass, which would enable them to see it at the distance of 1 inch. In this case the magnifying effect would be $\frac{72}{1}$, or 72 times.

Telescopes. But the instrument which we have now fitted up is precisely a telescope, the large lens being its object-glass, and the small one used by the observer its eye-glass; and hence the magnifying power of such an instrument is always equal to the focal length of the object-glass divided by the focal length of the eye-glass. The image formed by such a telescope is inverted, which is of no consequence when we look at the heavenly bodies, and it is therefore called an *astronomical telescope;* but in looking at the dial-plate, and at terrestrial objects, the inversion would be disagreeable; and it is therefore usual to make the image erect, by using either a concave eye-glass, or three or more convex eye-glasses. In the former case it is called the *Galilean telescope*, and in the latter a *terrestrial telescope.* Dioptrics. Astronomical. Galilean.

When the distance of the object is not very great, or when the focal length of the lens bears a considerable proportion to the distance of the object, the magnifying power of a lens, when the eye views the image formed by the lens at the distance of 6 inches, will be the following. Subtract the focal distance of the lens in feet from the distance between the image and the object, and divide the remainder by the same focal distance. By this quotient divide twice the distance of the object in feet; and the quotient will express the magnifying power, or the number of times that the object has been increased in apparent magnitude by the lens. Their magnifying power.

The very same observations apply to images formed by concave mirrors; and hence a single concave mirror becomes the simplest form of the reflecting telescope, the eye viewing the image which it forms. In the case of such images the body or the head of the observer must be placed between the object and the image, so that in order to use a single concave mirror, we must either make the mirror so large that the observer's head will not obstruct all the light, or we must make the reflection a little obliquely, or, what is done in practice, we must by means of a small plane mirror or a prism reflect or refract the rays to one side, so as to allow the observer to look at the image formed by the concave mirror without obstructing the rays in their passage from the object to the mirror, the quantity obstructed by the plane mirror or prism being too small to do any injury. If we view the image through a convex lens, so as to magnify it still more, the mirror and the lens will constitute a *reflecting telescope.* Reflecting telescopes.

Sect. IV.—On the Form of the Images of Objects produced by Lenses of Different Sizes.

Various optical writers[1] have treated of the images of objects, such as lines and surfaces; but, in so far as we know, no writer has treated of the shape and condition of the image of solids, such as the human figure, or of landscapes, the parts of which are placed at different distances from the lens or mirror by which they are formed. To the photographer, and to the public who employ him, this subject is one of fundamental importance, whether the object to be delineated is to be looked at as a single picture, or consists of binocular images to be raised into relief by the stereoscope. Form of images by large lenses.

The images of solid objects, or objects in relief, formed upon a plane surface, differ in many respects from the objects themselves. Science the most profound, and art the most inventive, have been combined, and in a great degree successfully, in executing lenses for telescopes, microscopes, and photographic cameras; but even when a lens is optically perfect, all points of the object placed at different distances from the lens will be represented in the image with different degrees of distinctness. The same is true of the images of objects seen by the most perfect eye when fixed on one point of the object. By changing its focus, however, if one eye is used, or, if two eyes are used, by converging the optic axis upon every point of the object in rapid succession, a distinct view of every part of it is obtained. This, however, cannot be done with the images of lenses; and hence it is impossible to form upon a plane surface the image of any object in which all the parts shall be equally distinct.

[1] Smith's *Complete System of Optics*, vol. i., p. 238; and vol. ii., p. 83.

Dioptrics. Following the geometrical principles of perspective, a correct picture of any object whatever upon a plane surface is obtained by drawing lines from the point of sight through every point of the object to that plane. Such a picture, thus stippled as it were, will be more distinct than any picture formed in the most perfect camera, because every point will in the one case be equally and perfectly distinct, while in the other those points alone which are equidistant from the lens will be distinct, all the rest being little discs of light, increasing in diameter with their distance from their true foci. As the images seen by the human eye are formed by a lens, whose aperture is the pupil, about one-fifth of an inch in diameter, we may regard it as a correct representation of external objects, not differing perceptibly from the perspective picture. For the same reason, we may consider the image of an object formed by a lens *one-fifth* of an inch in diameter as a correct representation of it.

If we now, in perspective, take a new point of sight one-fifth of an inch distant from the first, and draw lines as before from every point of the object supposed to be fixed, the perspective representations of it on the former plane will be changed, the two pictures will be dissimilar, and the similar points of the one will not coincide with the similar points of the other. For the same reason, if we look with one eye at the same object from two different points one-fifth of an inch distant, we shall obtain two views of this object equally dissimilar. The dissimilarity of the two pictures will increase with the distance of the two points of sight; and if the points of sight are distant $2\frac{1}{2}$ inches, the dissimilarity will be considerable. But the two eyes of man are distant $2\frac{1}{2}$ inches, and therefore the pictures of objects seen by each eye must be very dissimilar, the right eye seeing parts on the left side of a statue, for example, which are not seen by the left eye, and the left eye seeing parts on the right side of the statue which are not seen by the right eye. If we wish, therefore, to have a picture of any solid object exactly the same as it is seen with our two eyes, we must take it with two lenses one-fifth of an inch in diameter, placed at the distance of $2\frac{1}{2}$ inches, and having their axes converged to the point of the object which we desire to see most distinctly. Or we may take the picture by a lens *three* inches in diameter, by means of two apertures one-fifth of an inch in diameter, the centres of which are *one inch and a quarter* distant from the centre of the lens, the line joining them being horizontal. The picture thus taken will not be so distinct as one taken with the single lens of the same diameter.[1]

These facts being admitted as rigorously true, let us suppose that a perfect lens *four* inches in diameter is employed to produce upon a plane surface, the ground glass of a camera for example, the image of any object, lineal, superficial, or in relief, the diameter of the pupil being one-fifth of an inch. Then, as there will be in the lens several hundred areas (400 if the apertures are square) equal to that of the pupil, the image formed by the lens will be a compound image, or a combination of 400 perspective views of the object, taken from 400 different points of sight, each distant $\frac{1}{5}$th of an inch from its neighbour, and all those formed by the margin of the lens such as seen from points of sight 3 inches and four-fifths distant from each other. Such a jumble of incoincident images cannot under any circumstances be a true representation of an object, whether dead or alive. This view of the question, founded on the principles of *perspective*, will be more intelligible if we consider the subject in its *optical* aspect.

Let LL′ (fig. 48) be either the horizontal or the vertical section of a lens, and let ABDEC be the similar section of a solid cylinder ABCD, terminated by a cone CED, placed before the lens in order to have an image or picture of it taken upon a plane surface behind the lens. Prolong the lines EC, ED, till they meet the lens at the points *c*, *d*, and CA, DB till they meet it at the points *a*, *b*. If we now cover all the lens except the central portion *ab*, or use a lens of the diameter *ab*, the image of the object ABE will be *a circle*, because not a single ray from the lines AC, BD, or CE, DE—that is, from the surface of the cylinder or the cone—can reach the lens *ab*. In like manner, if we cover all the lens except *cd*, all the rays from AC, BD—that is, from the surface of the cylinder—will fall upon the lens *cd*, but none of the rays from EC, ED, the surface of the cone. But when the whole lens L′L is exposed, the rays from EC, ED will fall upon it, and have their image formed behind the lens. The image of the solid thus formed upon a plane, such as the ground glass of a camera, will be represented by a circle corresponding to AB, surrounded by a luminous ring, whose external diameter represents the surface of the cylinder, and a second ring whose external diameter represents the surface of the cone. If the object ABDEC is viewed by the eye, the diameter of whose pupil is *ab*, the circular end AB of the cylinder would alone have been seen; so that it is obvious that the images of objects must vary with the diameter of the lenses which produce them. These results have been confirmed by direct experiment.

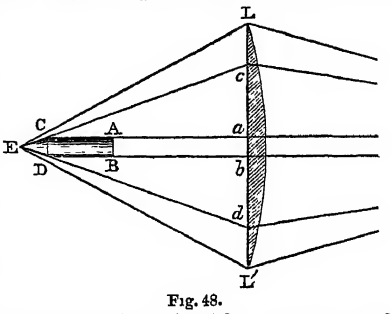

Fig. 48.

Let us now apply these principles to pictures of the human bust taken by a photographic camera. The human face and head, or bust, consists superficially of various lines and surfaces, inclined at all angles to the axis of the lens by which their image is to be formed upon a plane surface. A true perspective representation of the human head placed at AB will be given by a lens *ab*, whose diameter is equal to that of the pupil of the eye. From such a portrait all surfaces, such as AC, BD, EC, ED, will be excluded, because no rays from them can fall upon *ab*; but if we use the whole lens LL′, all these surfaces, and all those of an intermediate inclination, between AC and EC, and between BD and DE, will be introduced into the portrait. If LL′ is a horizontal section of the lens, the marginal parts between *a* and L might introduce into the portrait the left eye, the left ear, or the left side of the nose, which are not visible in a true perspective representation of the head; and for the same reason the marginal parts between *b* and L′ might introduce into the portrait the right eye, or the right ear, or the right side of the nose, which are not visible in a true perspective representation of the head; or all these features will be enlarged or widened horizontally, because they subtend a greater angle, as seen from the marginal parts of the lens. If LL′ be a vertical section of the lens, the top of the head, the upper part of the lips, and the eyelids will be introduced into the portrait by the upper marginal part of the lens; while the lower part of the nose, the interior of the nostrils, the lower part of the upper lip, and the lower part of the chin will be introduced by the marginal parts *b*L′ of the lens. The same is true of all other sections of the lens; and a monstrous representation will thus be obtained of the human head, the monstrosity increasing with the size of the lens. The form and character of portraits will thus vary with the shape of the lens; so that by making it circular, oval, square, rectangular, triangular, or any irregular form, we may produce remarkable modifications of photographic portraits. A round and swelled face might

[1] See *Edinburgh Transactions*, vol. xv., p. 365.

Dioptrics.

be improved by a lens whose length is three or four times its breadth, and a narrow and pinched face might be improved by a large circular lens.

The hideousness of photographic portraits is universally admitted. A distinguished writer speaks of the *terrible reality* of photography, adopting the general idea that the look of age and suffering exhibited in sun pictures arises from the unsteadiness of the sitter, and the necessary constraint of feature and of limb under which the victim submits to the operation. The true cause, however, modified doubtless by others, is to be found in the size of the lens, however perfect it may be.[1]

There is another defect in large lenses which requires to be mentioned. When pictures of trees, of shrubs, and flowers, or any other object smaller than the lens, are taken, the images of these objects, though absolutely opaque, are transparent; and leaves and stems, and small objects behind them, are seen like ghosts through the photographic image. This will be understood from the annexed figure, in which LL′ is a large lens, and AB an object whose picture is to

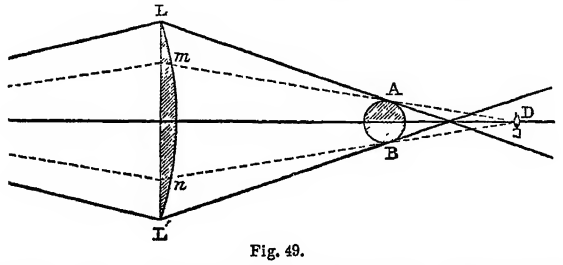

Fig. 49.

be taken by it. It is obvious that rays from a small object D situated beyond AB, will fall upon the marginal parts L*m*, L′*n* of the lens, which will form an image of it in front of the image of AB, so that AB will appear transparent.[2]

The preceding observations, *mutatis mutandis*, are equally applicable to mirrors or specula, which are sometimes employed for taking photographic pictures.

Having described the nature of images taken by large lenses,[3] it is of importance to notice certain properties of small lenses which render them peculiarly valuable in photography, or other purposes where a very correct picture of objects is required. If we could illuminate objects sufficiently, or give a very high degree of sensitiveness to the collodion or other material for the reception of their images, a small pin-hole, without any lens at all, would give the most accurate picture of objects of all kinds, whether lineal, superficial, or solid.[4] In cameras with two large achromatic lenses, the light has to pass through a great thickness of glass, which may not be altogether homogeneous, and which, if it is not, must deform the image. The light, too, has to pass through *eight* surfaces, which may not be truly spherical, and, whether so or not, must scatter light in all directions upon the sensitive plate. If the optical axes of these surfaces are not perfectly coincident, the image must be injured; and whether they are or not, the lights reflected from them must fall upon the sensitive plate. In addition to these evils, the difficulty of keeping away from the sensitive plate all extraneous light is in proportion to the size of the lens. From all these imperfections small lenses are to a great extent free; and we have no doubt that the time is approaching when a single achromatic lens *one quarter of an inch in diameter* will be in universal use. In proof of this, we have now before us a photograph taken in sixty seconds with a single lens of rock-crystal,[5] not achromatic, and which is far superior to all others of the same person (and they are numerous) taken by the first photographic artists with the most perfect cameras. With these facts before us, we have no hesitation in expressing our conviction that the photographer who has the sagacity to perceive the defects of his instrument, the honesty to avow it, and the skill to remedy them by the researches of optical science, will take a place as high in photographic portraiture as that of a Reynolds and a Lawrence in the sister art.

Spherical Aberration.

Part III.—On Spherical Aberration, and Caustic Curves.

The rules which we have already given for finding the foci of lenses and mirrors, are strictly applicable only to rays that pass near the axis of the lenses and mirrors; and this may be readily proved by the method of finding the refracted and reflected ray which we have explained and used.

Sect. I.—On the Spherical Aberration of Lenses.

Spherical aberration of lenses.

In order to prove and illustrate the preceding truth, we shall suppose parallel rays to be incident on a mass of glass MNOP (fig. 50) in which there is only one refraction at its first surface, and we do this both to avoid the confusion of lines, and because it is perfectly sufficient for the purpose of explanation. Let RS be the axis of the spherical surface MN, passing through S, its centre of curvature; and if we consider it a ray, also, it will go on to F without any refraction. Let RB be a ray falling on the refracting surface at a distance from the axis RS, and parallel to it. From the point of incidence B draw BS, which will be perpendicular to the surface at B, and take BG three-fourths of BR, BG being to BR as 1 is to 1·500, the index of refraction. From G draw GD parallel to BS, and making BD equal to BR, through the points D and B draw B*f*C for the refracted ray. Do the very same thing for the ray RB′ falling on the point B′, and parallel to RS, and equidistant from it, and B′*f*A will be the refracted ray.

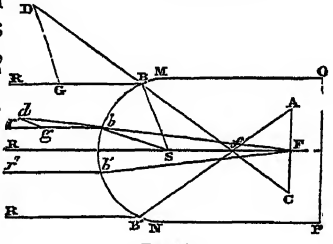

Fig. 50.

If we now take two rays *rb*, *r′b′* near the axis, and parallel to and equidistant from it, and apply the same method of projection to them, we shall find the refracted rays to be *b*F, *b′*F crossing the axis, and converging at a point F, more remote from the refracting surface than *f*. If we draw through F a line AFC, perpendicular to the axis, then A and C being the points where the marginal or most remote rays which fall on the surface MN meet AFC, and F being the focus of those nearest the axis, the distance *f*F is called the *longitudinal spherical aberration*, and AC the *lateral spherical aberration* of the lens.

These results may be obtained experimentally by covering up with a circle of black paper, all the central parts of the spherical surface, leaving a clear marginal ring corresponding with BB′. If the surface thus limited is exposed to the solar rays, we shall find a pretty distinct picture or

[1] The photographic picture of a cube taken by a lens of a greater diameter than the cube, will show *five* of its sides, when a true perspective representation of it is simply a single square of its surface.

[2] See Sir D. Brewster's *Treatise on the Stereoscope*, p. 175, where this phenomenon is more fully explained.

[3] Lenses of *nine* and even *twelve* inches diameter have been used in photography.

[4] See *Treatise on the Stereoscope* already referred to, p. 137.

[5] A single lens of rock-crystal should have its radii as 14 to 1, which is nearly a plano-convex, the flattest side being turned to the object.

Spherical Aberration.

image of the sun formed at *f*, which, from a cause which we shall soon explain, will be highly coloured at the edges. If we now remove the black circle from the surface MN, and cover the outside surface with black paper, excepting a small opening in the vertex of the lens, where the axis RS cuts it, and expose the lens to the sun's rays, we shall find the image of the sun distinct at F, and it will be less coloured than the image formed at *f*, from another cause.

If we now expose successive rings of the surface MN to the sun's light, shutting up all the rest of the lens, we shall find that the ring nearest the axis will have its focus near *f*, between *f* and F; the second ring, its focus still nearer F; the third, its focus still nearer F; and so on, till the last ring will give its image of the sun close to F. Hence it follows, that there will be distinct images of the sun formed by each ring, and occupying the whole space *f*F; and, therefore, if we expose the whole surface MN to the solar rays, the image of the sun must be extremely confused and indistinct; and if received upon a sheet of white paper placed at AC, it will consist of a bright disc at F, surrounded with a broad halo of light, becoming fainter and fainter towards A and C.

As this is true of every spherical surface whatever, it follows that every image formed by a spherical surface or lens, and every object seen through it, must be indistinct, from the confusion of rays produced by spherical aberration. As this indistinctness increases with the aperture of the lens, or the distance of the marginal rays from the axis, we may remove it to a certain degree by limiting the aperture, or using smaller lenses; but excepting in the case of the sun or any highly luminous body, this diminution of the aperture would injure vision, from the want of light, especially in microsopes and telescopes; and hence it becomes an object of the highest importance in optics, and it is one which has occupied much attention, to discover methods of diminishing or correcting the spherical aberration of lenses.

Philosophers have therefore been led to calculate with accuracy the amount of spherical aberration in lenses of different forms, and having different sides exposed to the incident rays. The following are the results which they have obtained, and they may be readily verified either by experiment, or by tracing the refracted rays through large diagrams of lenses of different shapes.

Forms of lenses of least and greatest aberration.

1. In a *plano-convex* lens (such as that shown at E, fig. 22.), whose *plane side is turned to parallel rays*, or to distant objects, if it is intended to form an image of them in its focus; or with its plane side turned to the eye, if it is to be employed as a single microscope or magnifier,—the *spherical aberration* is $4\frac{1}{2}$ *times its thickness*, or the *greatest* that can be obtained from it. This is called its *worst* position.

2. In a *plano-convex* lens, whose *convex side is turned to parallel rays*, the spherical aberration is only $1\frac{17}{100}$ths of its thickness, or the *least* that can be obtained from it. This is called its *best* position.

3. In *double convex lenses* with equal convexities, the spherical aberration is $1\frac{67}{100}$ths of their thickness, greater than that of a plano-convex lens in its best position.

4. In *double convex lenses* having their radii as 2 to 5, the spherical aberration will be the same as in a *plano-convex* lens in its *worst position*, if the flattest side, or that which has its radius 5, is turned towards parallel rays; and it will be the same as that of a *plano-convex lens* in its *best position*, if the surface whose radius is 2 is turned to parallel rays.

5. The *lens of least spherical aberration* is a double convex one, the radii of whose surfaces are as 1 to 6, having the surface whose radius is 1 *turned towards parallel rays*. In this, which is its best position, the aberration is only $1\frac{7}{100}$ths of its thickness. But if the side with the radius 6 is turned towards parallel rays, the aberration will be $3\frac{45}{100}$ths of its thickness.

Spherical Aberration.

If we determine the virtual focus of the central and marginal rays for a concave surface (as in fig. 50), we shall find that the spherical aberration is exactly the same for *concave* as for *convex* lenses; and hence all the preceding results are equally applicable to them.

If we suppose that the lens of least spherical aberration (as in art. 5) has an aberration expressed by unity, the comparative aberrations of other lenses will be as follows:—

Double convex or concave with radii as 1 to 6, in *best position*	1·000
Plano-convex or concave in *best position*	1·081
Double equi-convex or equi-concave	1·561
Plano-convex or concave in *worst position*	4·206

As a general rule for all lenses already made, and whose focus it is inconvenient to alter, the *most convex surface* should always be placed *towards parallel rays* when the lenses are used singly.

Aberration with different media.

The preceding results are calculated on the supposition, that the lens is made of *glass* whose index of refraction is 1·500; but the numerical results vary greatly when we use transparent media of higher and lower refractive powers. When the index of refraction is 1·6861, which is nearly that of some of the metallic glasses, and of several precious stones, and of sulphuret of carbon nearly, the lens of *least spherical aberration* is not one which has its radii as 1 to 6, but one which is *plano-convex;* and when we come to higher refractive powers, such as those of *sapphire, ruby, garnet,* and *diamond,* of which lenses are now made for microscopes, and ought to be made for the eye-glasses of powerful telescopes, one of the surfaces of the lens of least spherical aberration must be concave. This will be seen from the following results which we have calculated from Sir John Herschel's formula,[1] viz., $\frac{R''}{R'} = \frac{2\mu^2 - \mu - 4}{2\mu^2 + \mu}$ where R″ and R′ are the radii of the surfaces of the lens of least spherical aberration, and μ the index of refraction.[2]

	Index of Refraction.	Ratio.	
Vacuum	1·000	1 to 1·00	equi-convex.
Tabasheer	1·100	1 to 1·31	
New fluid in amethyst	1·111	1 to 1·35	
Second do. in topaz	1·200	1 to 1·76	
Ice	1·300	1 to 2·43	
„ Water	1·3368	1 to 2·77	
Cryolite	1·350	1 to 2·93	
Fluor spar	1·400	1 to 3·60	
Plate-glass	1·500	1 to 6·00	
Quartz, Topaz	1·600	1 to 14·00	
Chrysolite	1·686	1 to infinity,	plano-convex.
Sulphuret of carbon	1·700	1 to −93	meniscus
Garnet, Ruby	1·800	1 to −12	
Glass—lead 2½, flint 1	1·900	1 to −7	
Zircon	2·000	1 to −5	
Diamond, Octohedrite	2·500	1 to −2·5	
Chromate of lead	3·000	1 to −2·1	
	3·500	1 to −1·6	
	4·000	1 to −1·5	equal radii.
	infinite	1 to −1	

But it is not merely the curvature of the lens of least aberration that changes its character and its magnitude,—the aberration itself suffers a very great variation. This will appear from the table already referred to in the article MICROSCOPE.

In the case of diamond the aberration must be next to nothing; but in order to obtain this great advantage, its second surface must be very concave, which diminishes

[1] *Phil. Trans.*

[2] See our article MICROSCOPE, vol. xiv., p. 771, for the numbers obtained by Mr Coddington, from indices of refraction from 1·4 up to 2·0.

Spherical Aberration.

greatly its magnifying power. We have no doubt that artificial glasses or other solids will yet be made by art, and that mineral bodies will be discovered which will have such a high refractive power, as to enable opticians to remove almost wholly the spherical aberration of single lenses.

Aberration of rays not parallel.

Hitherto we have spoken only of the aberration of parallel rays, the effect of which is invariably to shorten the focus of the marginal or exterior rays; but when the incident rays converge or diverge, the aberration diminishes, and the focus of the marginal rays continues to be nearer the surface than that of central rays, till the focus of convergence or divergence comes up to *two particular points in the axis*, at the first of which, as will be presently seen, the aberration disappears, and at the second of which, namely, the focus of parallel rays on the convex side, it is infinite. When the focus of convergence or divergence is situated between these points, the effect of aberration is to lengthen the focus of marginal rays, and shorten that of central rays, the focal distance of the latter being now shorter than that of the former. These results are true for all curvatures and all indices of refraction.[1]

Sir John Herschel has given the following general rule for all double convex or concave lenses, and for all meniscuses and concavo-convex lenses in which the sum of the curvatures of their surfaces is greater than $\sqrt{2\mu+3\mu^2}$ times their difference (μ being their index of refraction). *The effect of aberration will be to throw the focus of marginal rays more* TOWARDS the incident light *than that of central ones, when the lens is of a positive character, or makes parallel rays converge; but more* FROM *the incident light if of a negative character, or if it cause parallel rays to diverge.*[2]

We have mentioned above, that there is a point in the axis, at which rays which diverge from it, and fall upon a concave surface, will have no spherical aberration. This will be understood from fig. 51, where BB′ is the first concave surface of a medium, C its centre, RCD its axis, and A a point in the spherical surface, where it meets the axis beyond the centre C. If we take two points R, F, such that RC is equal to the radius AC of the surface multiplied by the index of refraction, or RA to AF as the index of refraction is to unity, then all rays diverging from R, whether marginal or central, and falling upon the concave surface BDB′, will be refracted at BB′ in directions B*r*, B′*r*, which will proceed from the virtual focus F without any spherical aberration. This may be readily proved by the projection of the rays. Hence if, upon F as a centre, with any radius FE greater than FD, we describe a circle MEN, we shall have the second surface of a concavo-convex lens, which will be entirely free of spherical aberration. This is evident, as the rays refracted by the first surface BDB′ fall perpendicularly on the second surface, and suffer therefore no refraction.

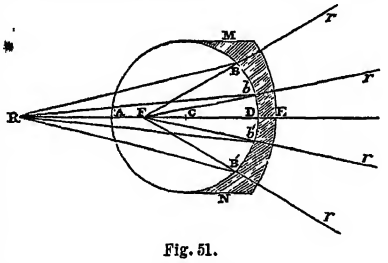

Fig. 51.

As there is a *concavo-convex lens* without aberration, for rays diverging from one point of its axis R (fig. 51), so there is a *meniscus* without aberration for rays converging to a particular point in its axis. Let RB, R′B′ (fig. 52) be rays converging to a point *f* in the axis R*Cf* of a convex refracting surface BDB′, whose centre is C. If we take *f*C so that it is to the radius CD as the index of refraction is to unity, then it may be shown, by projection or calculation, that the refracted rays RB, *rb*, whether marginal or central, will be refracted in lines BF, *b*F, having the same focus F, without any spherical aberration. Hence if, with F as a centre, we describe any circle, having its radius F*d* less than FD, we shall have the second or concave surface of a meniscus, which will have no aberration, because the rays BF, *b*F will pass through that surface perpendicularly, and suffer no refraction.

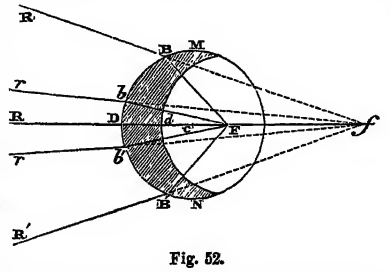

Fig. 52.

Spherical Aberration.

Owing to the injurious effect of spherical aberration on the performance of telescopes and compound microscopes, philosophers have sought to correct the spherical aberration of convex lenses by the opposite aberration of concave ones. We have already given drawings[3] of three doublets without spherical aberration, according to the calculations of Sir John Herschel. We shall now give an account of the method used by Dr Blair of correcting the spherical aberration in his compound object-glasses, and as they possess some historical interest, we shall give the same diagrams which he employed. Let AB (fig. 53) represent a convex lens receiving a pencil of diverging rays from the object S, and let D be the focus of marginal and F that of rays incident near the axis, such as ST. The greatest longitudinal aberration will therefore in this case be DF. Let GH (fig. 54) be now a concave lens, upon which are incident parallel rays SH, RK. Let P be the virtual focus of marginal rays, such as SH, and N the focus of rays near the centre, such as RK, so that PN will be in this case the longitudinal aberration. The convex lens in fig. 53 is in the position which gives the least spherical aberration, and the concave lens in fig. 54 is in the position which gives the greatest aberration. Hence, in order to make the aberrations equal, we must make the focal distance of the convex glass much shorter than that of the concave one, and if it is requisite to have the distance of the points F and N from the convex and concave lenses the same as it is shown in the figures, the object must then be placed much nearer the convex lens. Hence the image of the near object S is placed at the same distance from the convex lens in fig. 53, or the virtual focus of the concave lens in fig. 54, where it is shown as refracting parallel or infinitely distant rays.

Dr Blair on spherical aberration.

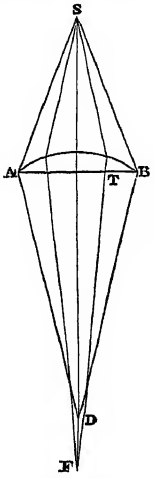

Fig. 53.

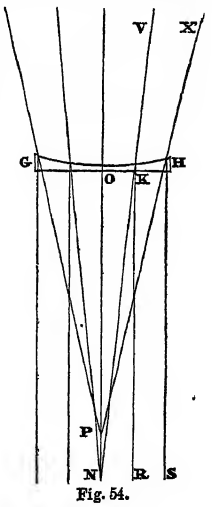

Fig. 54.

When the focal distance KN, therefore, for parallel rays, is equal to the distance TF for rays diverging from S, and when the aberration DF and PN are equal, then if the two lenses are combined (as in fig. 55), parallel rays SH, RK falling upon them, will be refracted to the focus S, without any spherical aberration. For if we suppose all the rays from S, which the convex lens (fig. 53) converges to D and F, to be returned back from these points to the lens, they would be refracted accurately to S. But the parallel rays SH, RK, after refraction by the concave lens (fig. 54),

[1] Sir John Herschel's *Treatise on Light*, sect. 288. [2] Ibid., 299. [3] Art. MICROSCOPE, chap. ii., vol. xiv.

Spherical Aberration.

in the directions HX, KV, are exactly in the same relative situation as the rays which we have supposed to be returned directly back from F and D are in at their incidence on the convex lens. Hence, when these lenses are combined, as in fig. 55, parallel rays falling on the concave lens, and after refraction incident upon the convex lens, will be refracted accurately to S without any spherical aberration.[1]

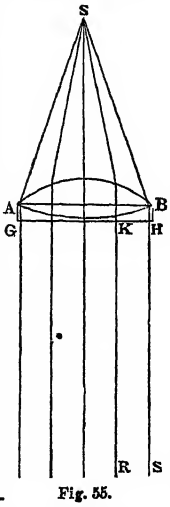

Fig. 55.

Lenses not spherical.

The difficulty of getting rid of the aberration of spherical surfaces induced opticians at a very early period to propose the construction of lenses that were not spherical, and that had such forms as to be entirely free of spherical aberration. As the marginal parts of spherical lenses refract the rays which fall upon them too much, the spherical aberration would obviously be removed or diminished by giving the surface any curvature in which the marginal parts become *less convex*. Now this is the character of two well-known curves, viz., the ellipse and the hyperbola, which, as Descartes discovered, may be employed in the formation of lenses in the following manner:—

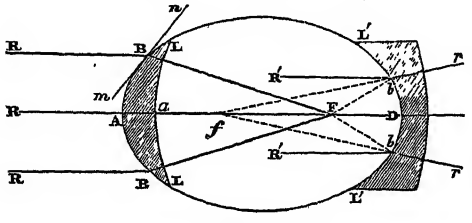

Fig. 56.

Ellipsoidal lenses.

If a lens LL (fig. 56) has the form of a meniscus in which the convex surface LAL is part of a prolate spheroid formed by the revolution of an ellipse, whose greater axis AD is to its eccentricity (or distance between its foci F, *f*) as the index of refraction is to unity, and if the other surface L*a*L is concave, and part of a sphere whose centre is F, the remoter focus of the spheroid; then rays RB, RA, RB, parallel to the axis RF of the spheroid or the ellipse, will be refracted by the convex spheroidal surface alone to the remoter focus F, and as these rays fall perpendicularly upon the second surface L*a*L, they will suffer no change whatever by its action, and continue their progress to F.

The same property belongs to a *concavo-convex* lens L'L', whose anterior or concave surface is part of a prolate spheroid of the same dimensions as for the meniscus, and having its convex side spherical, with *f* as a centre, and of any radius. In this case, all rays R'*b*, R'*b*, parallel to the axis and incident at *b*, *b*, will be made to diverge from the same virtual focus F, and will suffer no change of direction in passing out of the second or convex surface, as they all fall upon it perpendicularly.

These truths may be proved by the most elementary principles of the conic sections, or by drawing a tangent *mn* to the elliptical surfaces at B, *b*, and determining the refracted rays by the method already described.

Hyperbolic lens.

Upon the same principles a *plano-convex* lens may be constructed without spherical aberration as shown in fig. 57, provided its posterior surface L*a*L is part of a hyperboloid

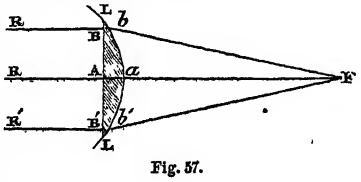

Fig. 57.

Plano-convex.

formed by the revolution of a hyperbola L*a*L, whose greater axis is to the distance between the foci as the index of refraction is to unity. Parallel rays RB, RA, R'B', will suffer no refraction at the plane surface BAB', but, at the points of the convex surface *b*, *b'*, will be refracted accurately to F, the further focus of the hyperboloid.

Spherical Aberration.

In like manner a *plano-concave* lens, having its concave surface part of a hyperboloid, will diverge all rays so as to have their virtual focus in one of the foci of the hyperboloid.[2]

Plano-concave.

The following elegant method of determining the figure of a refracting surface which shall refract marginal and central rays to the same focus is due to Huygens. Let R (fig. 58) be the focus of diverging rays, and F the focus to which it is required to refract them with accuracy. Take any point A as the vertex of the refracting surface required; the surface must be such that the incident and refracted rays RB, BF, have such a ratio to each other, that the excess of RB above RA shall be to that of FA above FB, as the index of refraction is to unity. In order to find the curve BAB which possesses this property, take in the axis RF any point D, and let DA be divided at the point C in such a manner that AC is to AD as unity is to the index of refraction, and from R and F as centres describe the arches of circles BDB', BCB', with the radii RD, FC, their points of intersection, B, B' will be in the required curve. In like manner, any other points in the curve may be found, and in order to convert it into a lens we have only to describe a spherical surface L*a*L, round the focus F as a centre, so that the refracted rays BF, B'F may suffer no change by passing through it perpendicularly. The curve BAB' gradually approaches to an ellipsoid as the radiant point R becomes more distant from the lens, and when it is infinitely distant the curve is the section of an ellipsoid, whose further focus is in F.[3]

Huygens' lens of no aberration.

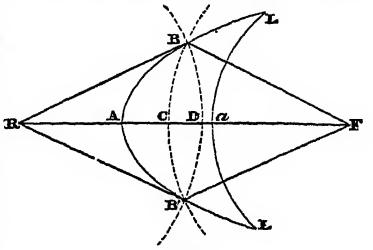

Fig. 58.

Various attempts have been made to execute lenses of other forms than spherical, but without decided success. Descartes has described machines for this purpose in the *tenth* chapter of his Dioptrics, but though he succeeded to a certain degree in his experiments, yet the art has never been acquired of producing figures sufficiently accurate for fine telescopes and microscopes.

Sect. II.—Spherical Aberration of Mirrors.

Spherical aberration of mirrors.

It has been already stated under "Catoptrics" in this article, that in all reflections from spherical surfaces it is only for the ray near the axis that the rules for finding their foci are correct, those which fall farther and farther from the axis having their foci nearer the reflecting surface. Hence all the images which are formed by spherical surfaces are indistinct from spherical aberration, like those formed by lenses, with this difference, that the images are not confused with the different colours which always accompany the refraction of lenses.

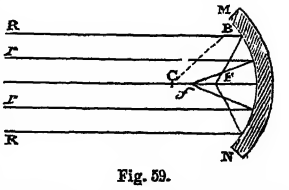

Fig. 59.

If MN (fig. 59) is a concave mirror, by which parallel rays R, R are reflected from its margin, and *r*, *r* from near its axis, it will be found, from

[1] See *Edinburgh Transactions*, vol. iii., p. 27.

[2] See Descartes' *Dioptrica*, cap. viii.

[3] See Newton's *Lectiones Opticæ*, part i., sec. iv., and Huygens' *Traité de la Lumière*, p. 111, &c.

Spherical Aberration.

a simple projection of the reflected rays, that R, R will invariably be reflected to a focus F nearer the mirror than the focus *f* of the central rays. The space F*f* is called the longitudinal or linear spherical aberration, and it will obviously become greater as the diameter of the mirror is increased, its focal length or its curvature remaining the same, and with its curvature when its diameter or aperture remains the same.

In mirrors, in all cases but *one*, the marginal rays have a shorter focus than the central ones, or, what is the same, have their focus nearest the reflecting surface. This case takes place when the radiant point is situated between the surface and the principal focus on the *concave* side of the mirror, in which case the focus of marginal rays is *farther from* the mirror than that of central rays.

There are only *two* cases in which spherical reflecting surfaces have *no* spherical aberration,—namely, when diverging rays radiate from the centre of a concave mirror or spherical surface, in which case they are reflected back without aberration to the point from which they came, without any aberration; and when they converge to the centre of a convex mirror or spherical surface, in which case they will be reflected back in lines diverging from the centre or virtual focus behind it, without any aberration.

One of these cases, namely, the first, is not an ideal one, but is actually applicable to practical purposes. For example, if rays diverging from F, the centre of curvature (not the focus) of the reflecting mirror MN (fig. 60), fall upon the mirror, they will be reflected to F, and pass through F towards a lens LL, which will refract them into a parallel beam LLRR, if FL is the focal length of the lens; or into a converging beam, so as to illuminate strongly any near object, if FL is greater than the focal length of the lens. This contrivance has been proposed for lighthouse illumination, where, in addition to the beam FLL radiating directly from F, the lens LL receives also the other beam FMN, both of which it unites in one parallel beam LLRR. In the accurate illumination of objects for the microscope this contrivance is also applicable; and hence for this purpose a *spherical* mirror is better than a mirror of any other form.

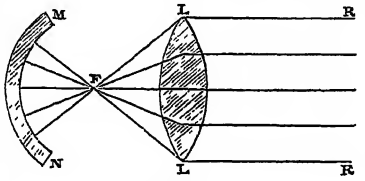

Fig. 60.

Paraboloidal mirrors.

As we cannot in the case of reflectors diminish their spherical aberration as we did in lenses, by giving a different shape to the two surfaces, it becomes of great importance to form the reflecting surface in such a manner as to remove the spherical aberration altogether. It is evident from the inspection of fig. 59, where CB is a perpendicular to the mirror at B, RMC the angle of incidence, and CBF the angle of reflection, that if the reflecting surface should be such that the line BF, drawn to a fixed point F, should always form equal angles with a line CB perpendicular to the mirror at the point of incidence, the parallel rays would all converge to the point F. Now the *parabola* is a curve which possesses this property, as shown in fig. 61. Let AEB be a parabola which forms a reflecting surface by its revolution round its axis RFE, and let R, R, R be parallel rays incident upon the paraboloidal surface at the points A, E, B. Then if F is the focus of the parabola, and GH a line touching the curve at A, it is a property of the parabola[1] that the angle GAR is equal to HAF, but GAR is the complement of the angle of incidence, and

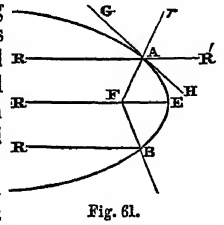

Fig. 61.

therefore HAF will be the complement of the angle of reflection, and consequently AF the reflected ray. As this is true for every ray parallel to the axis RFE, it follows that all parallel rays incident upon the surface of a paraboloidal mirror will be reflected accurately to the focus of the paraboloid. Spherical Aberration.

It may be shown, in like manner, that *convex paraboloidal reflectors* will reflect parallel rays so as to make them diverge from the virtual focus of the paraboloid. If, in fig. 61, we continue the line RA to R′, and also FA to *r*, it follows, from the above reasoning, that R′AH is equal to *r*AG, and that the reflected ray is A*r*, diverging accurately from the focus F. Convex paraboloidal mirrors.

When we wish to reflect diverging rays to a focus without aberration, we must have recourse to another solid of revolution,—namely, a prolate spheroidal surface formed by the revolution of an ellipse round its greater axis. In this case, rays diverging from one of its foci will be reflected accurately, without aberration, to the other focus. This will be understood from fig. 62, where R, F are the foci of an ellipsoid, AEB a section of the ellipsoidal surface, and GH a line touching the ellipse at A; then if rays diverging from one of its foci R, fall upon the reflecting surface at A, E, and B, they will be reflected accurately to the focus F, or if they radiate from F, they will be reflected to R. As it is a property of the ellipse[2] that the angle GAR is equal to HAF, then since GAR is the complement of the angle of incidence, HAF must be the complement of the angle of reflection, and AF the reflected ray. As the same is true of every other point of the ellipsoidal surface, it follows that all rays incident upon it from one focus will be converged without aberration to the other focus.

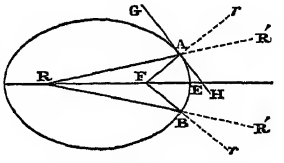

Fig. 62.

In like manner it may be shown, by producing RA to R′, and RB to R′, that rays falling upon a *convex ellipsoidal mirror*, and converging to one focus, will be reflected as if they diverged accurately from the other focus; that is, rays R′AR, R′BR, converging to R, will be reflected in diverging directions A*r*, B*r*, as if they diverged from the focus F, or rays *r*A, *r*B converging to F, will be reflected in directions AR′, BR′, as if they diverged from R as their virtual focus. Concave ellipsoidal mirrors.

If the concave surface of a mirror is a portion of a *hyperboloid*, a solid generated by the revolution of a hyperbola about its axis, rays converging to one focus will be reflected to the other focus. Let AEB (fig. 63) be a section of the hyperboloid, and RAR′, RBR′, rays converging to its focus; these rays will be reflected to its other focus F. Let GH be a tangent to the hyperbola at A, then by a well-known property of the hyperbola,[3] the angle GAR is equal to HAF; but the former being the complement to the angle of incidence, and the latter the complement to the angle of reflection, AF will be the reflected ray. For the same reason, if the rays *diverge* from the focus F, they will, after reflection, diverge in the directions AR, BR, as if they came from the other focus R′. Hyperboloidal mirrors.

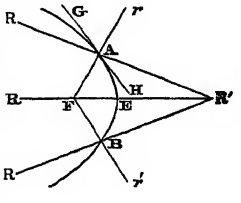

Fig. 63.

In a similar manner it may be shown, that in a *convex hyperboloidal mirror* AEB, rays diverging from one focus R′, will be reflected in directions A*r*, B*r*′ as if they diverged from the other focus F.

The preceding truths are of great practical use in the construction of optical instruments. In all reflecting tele-

[1] See Conic Sections, vol. vii., part i., prop. iii., cor. 3. [2] Ibid., part ii., prop. v., cor. 4. [3] Ibid., part iii., prop. v.

Caustics.

scopes, where parallel rays are required to be reflected to a single focus, it is necessary that the figure of the reflecting surface should be that of a paraboloid; and as in the specula of such telescopes the portion of the paraboloid which is requisite does not differ much from the same portion of a spherical surface that has the same focal length, artists have contrived particular methods by which the marginal parts of the spherical surface shall be worn down in the act of polishing, so as to convert the spherical into a paraboloidal surface.

In the reflectors of lighthouses, where a large surface is required to be used, a copper plate thickly plated with silver is hammered by means of a gauge to as correct a paraboloidal figure as possible, and a lamp being placed in its focus, the light which it radiates is reflected in a beam of considerable brilliancy.

Mirrors for microscopes.

In the construction of reflecting microscopes, where the image of a small object placed in one spot has a magnified image of it formed in another point, an ellipsoidal speculum is used; and Mr Cuthbert, an eminent London artist, has succeeded in giving to such small specula an accurate ellipsoidal form. Professor Potter has also succeeded, as we have mentioned elsewhere,[1] in giving specula a true ellipsoidal form, and has published an account of the method by which he was able to effect this important object.[2]

Sect. III.—On Caustic Curves formed by Spherical Reflecting and Refracting Surfaces.

Caustic curves.

When two or more rays of light cross one another at any point, they illuminate any reflecting substance placed in that point with their united light. Hence it follows, that when spherical surfaces converge the rays which fall upon them to different foci, these different foci must form so many illuminated points, if they are received on smoke, on white paper, or on water with any reflecting particles suspended in it. The lines which pass through these luminous foci, or rather the lines formed by the union of a great number of them, are called *caustics*, or *caustic curves*. As these curves are in reality a visible representation of the phenomena of spherical aberration, they possess considerable interest as experimental illustrations of that class of facts.

When diverging rays fall upon a spherical mirror, whose surface exceeds a hemisphere, the caustics formed by reflection are exceedingly beautiful. Let ACB (fig. 64) be

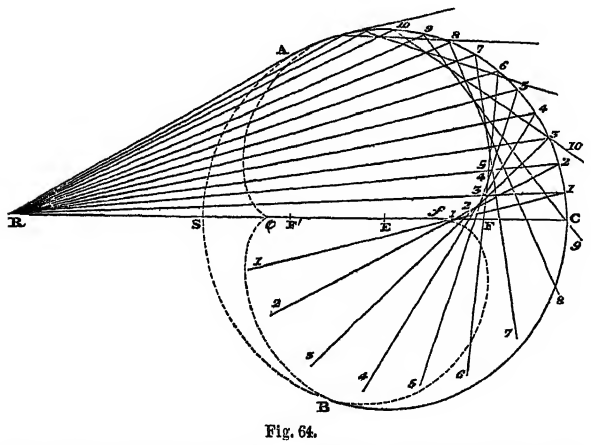

Fig. 64.

the section of such a spherical surface; whose centre is E, and whose principal focus for parallel and central rays is at *f*. Let a beam of light RAC, diverging from R, be incident on the upper part AC of this mirror, the beam consisting of the individual rays R1, R2, R3, &c., up to R10; and let the reflected rays 1-1, 2-2, 3-3, &c., be found by making the angle of reflection which they form with the perpendiculars drawn from 1, 2, 3, &c., to E, equal to the angles of incidence which they form with the same perpendiculars. We shall then have the directions, and also the foci and intersections of all the rays. The ray 10-10 does not meet the axis RC at all, but falling on the mirror at the point 3, will there suffer a second reflection. The ray 9-9 has its focus exactly at C, the vertex of the mirror, where it will suffer a second reflection; and so on with all the rest up to 12, which is the last which will suffer a second reflection. All the reflected rays, after 9-9, cross the axis, or have their foci at points gradually approaching to *f*, which is the focus of the central ray R1. As all the rays proceeding from R, but not drawn in the figure, which fall upon the other half CB of the mirror, at points corresponding to R1, R2, &c., will have their foci in the same points between C and *f*, there will be along that line a series of foci constituting a line of light becoming more intense towards *f*.

Caustics.

But the rays R 10, R 9, R 8 cross each other after reflection, and before they reach the axis, as shown in the figure, and hence there will be a beautiful curve of light A*f*, called a *caustic*, formed by the intersection of these rays. The other half of the mirror CB will form a similar caustic, and the projecting points *f* are called the *cusps* of these caustics, and C*f* their tangent.

If a small pencil of light, consisting of two contiguous rays, moves from RA towards the position RB, being incident successively at 9, 8, 7, 6, &c., the conjugate focus of this pencil, or that formed by the intersection of the two rays of which it consists, will move along the caustic curve A*f*, while the points where it crosses the axis RC, or its focus formed by its union with a similar pencil similarly incident on the other half of the mirror, will advance from C to *f*.

If we now consider ACB as a *convex* spherical surface, and place the radiant point R as far to the right of the vertex C as it is to the left of it in the figure, and if we project the reflected rays, we shall find that when traced backwards, they will intersect the *axis* and each other, in the very same manner as they do in the figure, forming an *imaginary* or *virtual* caustic, in place of a *real* one, the two being in every respect the same.

If, while the radiant point R remains as in the figure, we suppose the convex surface ASB to receive the incident rays, it will then be found, by projecting the reflected rays, that they will form an imaginary caustic AϕB, less than A*f*B, and joining it at the points A, B. This difference in size arises from the radiant point being in this case much nearer the convex surface than before.

Let us now suppose that the radiant point R recedes from the *concave* mirror ACB, the point *f* of the *cusps* will gradually approach to F, the tangent C*f* diminishing at the same time; and when R is infinitely distant, or the rays parallel, the point *f* will coincide with F, the focus of parallel rays. The same will take place in the case of the *convex* mirror ACB; but in the case of the convex mirror ASB, the point ϕ of the cusps will approach to F', and will coincide with it when R is infinitely distant.

If, in the case of the *concave mirror* ACB, the radiant point R now approaches to the mirror, the cusps *f* will approach to the centre E of the mirror, the *caustic* curve A*f* becoming flatter and flatter, and when R reaches E, there will be no caustic at all, in consequence of all the rays being reflected back to the centre, all their *foci* and *intersections* having united in that point.

In the case of the *imaginary* caustic AϕB, when R approaches to S, ϕ will also approach to S, the caustic approximating in form to the circular arch AS; and when

[1] Art. Microscope, chap. iii., vol. xiv.

[2] *Edin. Jour. of Science*, N.S., No. xii., p. 228.

Caustics. R reaches S, ϕ will also reach S, the caustic disappearing when it has reached that limiting form.

All that we have said is obviously applicable only to one section of the spherical mirror; but as the same is true of every section whatever, the caustic will not be a curve, but a surface formed by the revolution of the curves AfB round its axis fC, all the reflected rays being tangents to this surface.

We shall now consider the change in the appearance of the caustic, when the radiant point comes within the sphere of which the reflecting surface is a part, and when the mirror becomes a concave polished sphere. The effect thus produced is shown in fig. 65, RE being less than RS. In this case a remarkable double caustic will be formed,

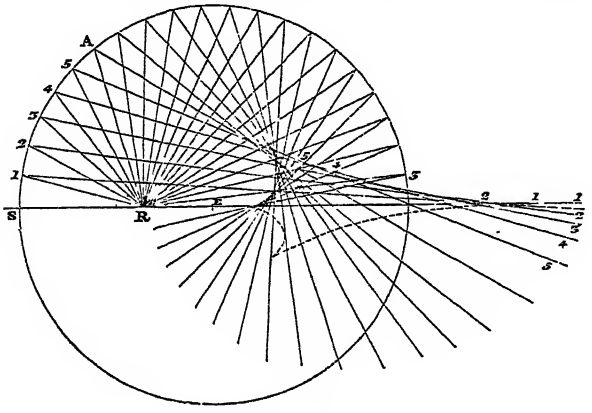

Fig. 65.

composed of a short one of the kind shown in fig. 64, and another with two long branches, one of which is shown at 1, 2, 3, 4, 5, the dotted line below the axis SE showing the other halves of the caustic, and long branches converging behind the mirror. Had R been placed nearer S than E, the branches 1, 2, 3, &c., would have diverged behind the mirror, having their virtual foci within the mirror. When R is half-way between S and E, the curved branches become parallel lines. When R comes nearer E the branches 1, 2, 3, &c., shorten; the smaller caustics also shorten; they both approach to the centre E, the long branches moving quickest, till at E, as we have already seen, all the rays from R are reflected back to the same point, and the caustics all disappear.

M. A. Delarive, in his ingenious dissertation on caustic curves,[1] has shown that caustics generated by parallel rays are *epicycloids*, formed by one circle rolling upon a fixed circle concentric with that of the mirror, and having a radius equal to half of its own. Dr Smith has shown that when the radiant point is at S, the caustic is an epicycloid whose generating circle is two-thirds of the radius of the mirror, and the fixed circle one-third of that radius.[2]

When the radiant point passes the centre E, the caustics shift their place to the opposite side of E, and present the same phenomena as before.

There is a curious property, however, involved in these phenomena, which we have represented in fig. 66, where the radiant point is supposed to be at F, a very little within the principal focus of a spherical mirror ACB. We have supposed the rays to diverge from a point *a little* within the principal focus, because it is only in this case that the rays F1, F1, at *a little* distance from the axis, may be reflected in directions 1-1, 1-1, exactly parallel. The rays F2, F2, falling at a greater distance from the axis, will be made to converge to a focus at $f2$, and rays F3, F3, to a focus $f3$, still nearer the mirror. If we now conceive rays flowing from F to fall on the mirror Caustics.

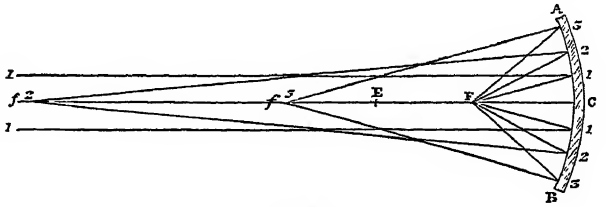

Fig. 66.

between the rays F1, F1, and the axis FC, these rays will diverge, because they radiate from a point a little within the principal focus, and hence we have one spherical mirror which has, under these circumstances, the paradoxical property of rendering a faint cone of diverging rays parallel, converging, and diverging, after reflection.

Caustics from cylindrical surfaces.

All that we have said of the caustics formed by the sections of spherical surfaces, are true of cylindrical surfaces, and by means of surfaces of this kind the phenomena of caustic curves may be beautifully exhibited. They are indeed often presented to the eye at the bottom of china vessels of a cylindrical form, when exposed to the rays of the sun or to the light of a candle. Owing to the depth of such vessels, the obliquity of the rays prevents the effect from being well seen; but we may take shallow cylindrical vessels, or make deep ones shallow by an artificial bottom of paper or pasteboard, or by filling them nearly with milk, or any other fluid with a white opacity, or with a fine white powder pressed into a smooth surface. In order to show the caustics, when the radiant point is placed within the cylindrical surface, a piece of card should be made to float upon oil in the cylindrical vessel, and a very minute wick inserted in the card at the points of the axis where we wish the radiant point to be placed. This wick, when lighted, will be the radiant point R in fig. 65, and the caustics will be beautifully formed on the surface of the white card.

The following method, however, of exhibiting caustic curves, we have found very convenient and instructive, and it has the advantage of allowing the radiant point to come within the cylinder. A piece of steel spring, highly polished, such as a watch-spring, is bent into a concave form, like AB (fig. 67), and is placed vertically with its lower edge resting upon a piece of card or white paper. It is then exposed to the solar rays, or those of any artificial light, so that the plane of the card MN passes through the luminous body, and the caustic curves will be seen finely displayed, varying with the distance of the radiant point, and with the reflecting arch AB. By altering, too, the curvature of the arch, and bending it into different known curves, either by applying a portion of its breadth to the required curves delineated upon a piece of wood, and either cut or burned sufficiently deep in the wood to allow the edge of the thin strip of metal to be inserted in it, a great variety of interesting phenomena may be observed. The brightest reflector is a thin strip of polished silver or plated copper. Gold and silver foil will also answer, or a strip of mica. A cylindrical section of a wide glass tube or a bottle, especially if a piece is cut out of them to allow the incident rays to pass to the reflecting surface in the plane nearly of the base of the cylinder, will produce the caustic curves in great perfection. The caustic curves produced by a highly

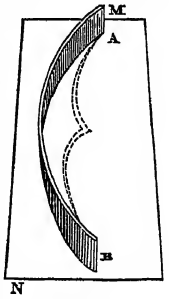

Fig. 67.

[1] *Dissertation sur la Partie de l'Optique qui traité des courbes dites Caustiques*, p. 84, Geneve, 1823. This interesting dissertation contains an account of the labours of preceding mathematicians, including Malus and Gergonne, and merits the attention of those who wish to prosecute the subject mathematically.

[2] *Complete System of Optics*, vol. i., p. 174.

Caustics. gilt or polished metallic ring, such as the ring of a bell handle, are exceedingly beautiful, the phenomena of a convex and a concave surface being here united.

Caustics formed by Refracting Surfaces.

It is evident, from what has been said of caustics formed by reflection, or *Catacaustics*, that analogous curves must also be formed by spherical refracting surfaces, which have been called *Diacaustics*. In order to explain these curves, we shall take the case of diverging rays falling upon a spherical surface, as shown in fig. 68, where DBD is the spherical surface, C its centre, R the radiant point, RD,

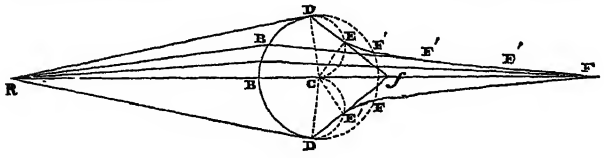

Fig. 68.

RD, two extreme rays touching the sphere, and refracted in the directions D*f*, D*f*; and RB, RB, other rays nearer the axis, and refracted in the directions BF, BF. If we join CD, CD, and drawing the semicircles DEC, DE′C, make the lines CE, CE′ in the same proportion to CD as unity is to the index of refraction, the caustic will begin at E, E′, and extending in the directions EF′, E′F, will approach to the axis RC till it meets it at the principal focus F.

The caustics formed by the two refractions of a sphere, or of a cylinder (in a plane perpendicular to its axis) are shown in fig. 69, where ACB is the spherical section, E its

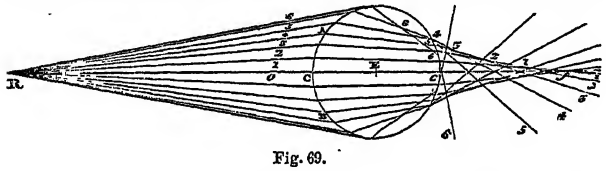

Fig. 69.

centre, R the radiant point, and RC the ray which touches the spherical surface. This ray will be refracted by the first surface in the direction 6-6, and by the second surface of the sphere at 6; the other rays, R5, R4, &c., will be all refracted in the directions indicated by the numerals 5, 4, &c., and their various intersections will form the caustic 6, 4, 3, 2, 1, *f*, each ray crossing the next ray before it cuts the axis, *f* being the focus or the point where the rays nearest the axis cut it. The luminous figure bounded by the intersection of the successive rays, is composed of the two bright caustic curves. Within these caustics there is also much light arising from the intersections between the caustics and the axis; but as there are no intersections without the caustics they are bounded by darkness.

When parallel rays fall upon the spherical section ACB, the caustic commences at the extremity of a diameter perpendicular to the axis of the section, because the extreme ray suffers refraction at that point, and will intersect the nearest a little within it; and they extend, as in fig. 69, to the principal focus of the sphere for rays near the axis. The real caustic will be the surface formed by the revolution of the curves round the axis E*f*; the section of this surface will be a luminous point at *f*, but at the posterior part it will be a luminous circle vividly depicted on the sphere. M. Delarive has pointed out a method of determining the index of refraction of solid spheres, or of hollow spheres containing different fluids, by measuring the diameter of this luminous circle, which is smaller in fluids of high than in those of low refractive power. The phenomena of caustics formed by refraction, may be distinctly exhibited by exposing to the rays of the sun, or a strong artificial light, a globe of glass filled with any fluid, or a solid transparent sphere, or the widest part of a round glass decanter. With all these bodies the whole of the luminous figure will be clearly seen. If we use a cylinder full of water, such as a tumbler or a cylindrical bottle, we shall see the caustic curves formed upon a white surface held parallel to the cylindrical surface of the fluid, the light falling upon the cylindrical surface in the same plane. Chromatics.

Part IV.—On the Refraction of Compound Light, or the Doctrine of Colours and the Prismatic Spectrum.

In the preceding pages we have considered white light, whether emanating directly from the sun or from artificial flames, or consisting of the same rays reflected and modified by other bodies, *as a simple element*, all the particles of which had the same index of refraction, or suffered the same change of direction when refracted by any transparent body. This, however, is not the nature of light. White light, as emitted by the sun or other luminous bodies, is a very *compound element*, all the parts of which possess very different properties, and these properties are of a very remarkable and interesting kind. The power which causes the reflection of light from polished metallic bodies is not capable of decomposing it, unless when it enters the substance of the metal; but the power which produces refraction is peculiarly influential in separating compound white light into its elements. The same decomposition may be effected by the *interference* of rays of light, by *absorption*, and by another principle of analysis which has been called *dissection*. The two first of these processes of analysis decompose compound light of different degrees of refrangibility, while the two last decompose compound light whose rays have the same refrangibility. Chromatics.

Sect. I.—On the Decomposition of Light, and the Different Refrangibility of its Rays.

The constituent parts or colours which compose white light are seven in number—*red*, *orange*, *yellow*, *green*, *blue*, *indigo*, and *violet*. These colours have been long observed and studied in the rainbow, and in the refractions produced by lenses and prisms, but till the time of Sir Isaac Newton no satisfactory explanation had been given of their origin and properties. Descartes had found that colours similar to those of the rainbow were produced by prisms, and he endeavoured to explain them by saying that the particles of the medium, or matter which transmits light, endeavour to revolve with so great force, that they cannot move in a straight line, whence comes refraction; and that those particles which endeavour to revolve more strongly produce a *red* colour, those that endeavour to move a little more strongly produce *yellow*, and so on with the other colours. Now this explanation, as Dr Whewell[1] has justly remarked, though it contains a gratuitous hypothesis respecting the cause of refraction, yet it proves that Descartes considered the different colours as produced by different degrees of refraction. In like manner Grimaldi, as the same author has observed, explains colours by saying "that the colour is brighter where the light is dense; and the light is denser on the side from which the refraction turns the ray, because the *increments of refraction* are greater than the rays that are more inclined;"[2] that is, that the blue rays are more refracted than the red rays. We cannot agree, however, with Dr Whewell in the opinion, that this explanation of Grimaldi's might give an explanation of most of the facts, but one much more erroneous than a develop- Seven colours.

[1] *Hist. of Inductive Sciences*, vol. ii., p. 350.

[2] Ibid., p. 352.

Chromatics

ment of Descartes' views would have been." It appears to us quite manifest, that both Descartes and Grimaldi had a vague sentiment that the different colours were produced by different degrees of refraction, and that Grimaldi's is the more distinctly expressed of the two; but we cannot for a moment agree with the author above quoted, "that Descartes was led very near the same point with Newton." The sentiments expressed by Descartes and Grimaldi were mere notions of the moment, which authors often throw out without much thought, and which are employed in future times to pervert the history of science. If these two authors really thought that colours were produced by different degrees of refraction, why did they not, as they did other opinions, submit them to the test of an experiment, which required neither thought nor labour, and the means of making which were in their hands? Sir Isaac Newton was well acquainted with the writings of Descartes, and so much with Descartes' *notions* about colours, that the examination of them was the object which he had in view in purchasing his prisms. He never refers to them as anticipatory of his own discoveries; and we must therefore continue to give Sir Isaac the *undivided* merit of the discovery of the unequal refrangibility of light, as well as its experimental establishment.

We shall now proceed to give our readers some account of this great discovery, and we shall make no apology in doing this to some extent in Sir Isaac Newton's own words, abridging his descriptions where they are redundant or have become unnecessary, and omitting the demonstration of some of his propositions. We are induced to do this also because they exhibit the finest model of experimental research, and should be studied by every person who is desirous of investigating truth with diligence and patience.

Unequal refrangibility of light.

"1. *The light of the sun consists of rays which differ in colour and refrangibility.*—In a very dark chamber, at a round hole F (fig. 70), about one-third of an inch broad,

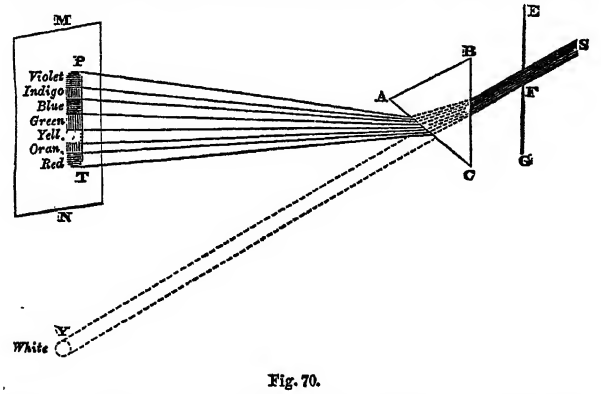

Fig. 70.

made in the shutter of a window, I placed a glass prism ABC, whereby the beam of the sun's light SF which came in at that hole, might be refracted upwards, toward the opposite wall of the chamber, and there form a coloured image of the sun, represented at PT. The axis of the prism was, in this and the following experiments, perpendicular to the incident rays. About this axis I turned the prism slowly, and saw the refracted or coloured image of the sun, first to descend, and then to ascend. Between the descent and ascent, when the image seemed stationary, I stopped the prism, and fixed it in that posture, for in that posture the refractions of the light at the two sides of the refracting angles,—that is, at the entrance of the rays into the prism, and at their going out of it,—are equal to one another.

"Then I let the refracted light fall perpendicularly upon a sheet of white paper (MN) placed at the opposite wall of the chamber, and observed the figure and dimensions of the solar image (PT) formed on the paper by that light. This image was oblong, and not oval, but terminated by two rectilinear and parallel sides, and two semicircular ends. On its side it was bounded pretty distinctly, but on its ends very indistinctly, the light there vanishing by degrees. At the distance of 18½ feet from the prism the breadth of the image was about 2⅛ inches, but its length was about 10¾ inches, and the length of its rectilinear sides about 8 inches; and ACB, the refracting angle of the prism, by which so great a length was made, was 64 degrees. With a less angle the length of the image was less, the breadth remaining the same. It is also to be observed that the rays went on in straight lines from the prism to the image, and therefore at their going out of the prism had all that inclination to one another from which the length of the image proceeded. This image PT was coloured, and the more eminent colours lay in this order from the bottom at T to the top at P: *red, orange, yellow, green, blue, indigo,* and *violet;* together with all their intermediate degrees, in a continual succession perpetually varying."

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Hence "the light of the sun consists of a mixture of several sorts of coloured rays, some of which, at equal incidences, are more refracted than others, and therefore are called *more refrangible.* The red at T, being nearest to the place Y, where the rays of the sun would go directly if the prism was taken away, is the least refracted of all the rays; and the *orange, yellow, green, blue, indigo,* and *violet,* are continually more and more refracted as they are more and more diverted from the course of the direct light. For, when the prism is fixed in the posture above mentioned, so that the place of the image shall be the lowest possible, the figure of the image ought to be round, like the spot at Y, if all the rays that tended to it were equally refracted. Therefore, since it is found that this image is not round, but about five times longer than it is broad, it follows that all the rays are not equally refracted. This conclusion is farther confirmed by the following experiments:—

"In the sunbeam SF (fig. 71), which was propagated into

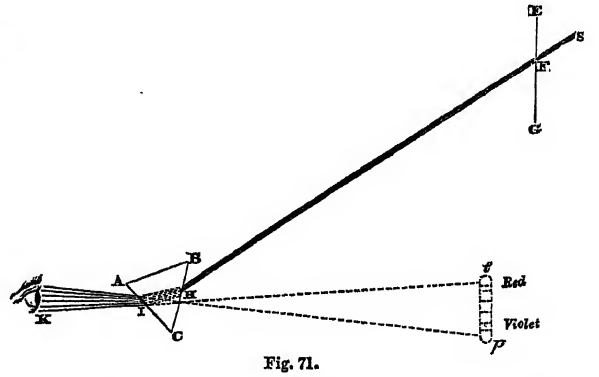

Fig. 71.

the room through the hole F in the window-shutter EG, at the distance of some feet from the hole, I held the prism ABC in such a posture that its axis might be perpendicular to that beam: then I looked through the prism upon the hole F, and turning the prism to and fro about its axis, to make the image *pt* of the hole ascend and descend, when between its two contrary motions it seemed stationary, I stopped the prism; in this situation of the prism, viewing through it the said hole F, I observed the length of its refracted image *pt* to be many times greater than its breadth; and that the *most refracted* part thereof appeared *violet* at *p;* the *least refracted* appeared *red* at *t;* and the *middle* parts *indigo, blue, green, yellow,* and *orange* in order. The same thing happened when I removed the prism out of the sun's light, and looked through it upon the hole shining by the light of the clouds beyond it. And yet if the refractions of all the rays were equal according to one certain proportion of the sines of incidence and refraction, as is commonly supposed, the refracted image ought to have

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appeared round. So then, by these two experiments, it appears that in equal incidences there is a considerable inequality of refractions."

2. *The light of the sky, or the light of the sun reflected from the first surface of bodies, and also the white flames of all combustibles, whether direct or reflected, differ in colour and refrangibility, like the direct light of the sun.*

3. *Homogeneal light is refracted regularly without any dilatation, splitting, or shattering of the rays; and the confused vision of objects seen through refracting bodies by heterogeneous light arises from the different refrangibility of several sorts of rays.*

4. *Every homogeneous ray considered apart is refracted, according to one and the same rule; so that its sine of incidence is to its sine of refraction in a given ratio; that is, every differently coloured ray has a different ratio belonging to it.*

Sir Isaac Newton has proved this by experiment; and in other experiments he has determined by what numbers these given ratios are expressed. For instance, if a heterogeneous white ray of the sun emerges out of glass into air; or, which is the same thing, if rays of all colours be supposed to succeed one another in the same line AC (fig. 72), and AD, their common sine of incidence in glass, be divided into *fifty* equal parts, then EF and GH, the sines of refraction into air of the least and most refrangible rays, will be 77 and 78 of such parts respectively. And since every colour has several degrees, the sines of refraction of all the degrees of red will have all intermediate degrees of magnitude from 77 to 77⅛; of all the degrees of orange from 77⅛ to 77¼; of yellow from 77¼ to 77⅓; of green from 77⅓ to 77½; of blue from 77½ to 77⅝; of indigo from 77⅝ to 77¾; and of violet from 77¾ to 78.

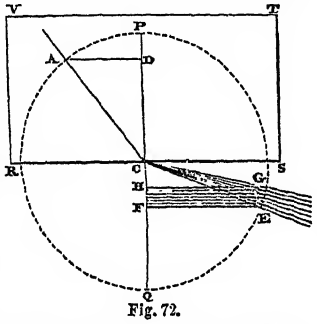

Fig. 72.

5. *Whiteness, and all gray colours between white and black, may be compounded of colours; and the whiteness of the sun's light is compounded of all the primary colours, mixed in a due proportion.*

Such is an abridged account of Newton's great discovery of the different refrangibility of light.

In examining the prismatic spectrum, it is difficult to discover the terminations or boundaries of the different colours. They pass into one another by insensible shades, and if any person were to lay down their apparent limits by the nicest observations, he would find, what has been recently discovered, that these limits vary with the state of the atmosphere, and with the altitude of the sun. Sir Isaac Newton, however, did make the attempt, and the following are the results which he obtained, we believe with crown or plate glass. We have added the results obtained long afterwards by Dr Wollaston[1] and Mr Fraunhofer[2] with flint-glass, which shows the difficulty of this class of observations:—

	Newton in Crown-Glass.	Fraunhofer in Flint-Glass.	Wollaston in Flint-Glass.
Red	45	56	
Orange	27	27	Red 57·6
Yellow	40	27	
Green	60	46	82·8
Blue	60	48	
Indigo	48	47	Blue 129·6
Violet	80	109	90
	360	360	360

The influence of these discoveries on the progress of optical science was very remarkable. They led Sir Isaac to discover that the cause of the imperfections of the refracting telescopes was the different refrangibility of the rays of light. If LL, for example, is a lens without spherical aberration, upon which parallel rays R, R, R of white light are incident, then it is obvious that the *violet*, or most refrangible rays, will be most refracted in directions L*v*, L*v*, crossing the axis at *v*, and there giving a *violet* focus of light. In like manner the *red*, or the least refrangible rays, will be refracted in directions L*r*, L*r*, crossing the axis at *r*, and there giving a *red* focus of light. In like manner, all the other rays will have foci of their own colour between *v* and *r*. If we draw the line *ab*, meeting the intersection of the extreme violet rays after their convergence with the extreme red rays before their convergence, it will cut the axis at a point *c*. The line *vr* is called the *longitudinal aberration of refrangibility*, or the *longitudinal chromatic aberration*, and *ab* is called the *lateral aberration of refrangibility*, or the diameter of the *circle of diffusion*, all the coloured rays being diffused over the circle of which *ab* is the diameter. The space *varb* is called the sphere of diffusion, and the section of it shown in the figure may be regarded as a parallelogram, on account of the smallness of the angles *r*L*v*, *r*L*v*, which are greatly magnified in the figure. Hence it may be easily shown that the longitudinal aberration *vr* is to the lateral aberration *ab* as the focal distance of the lens is to its radius or half its aperture.

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Imperfection of refracting telescopes.

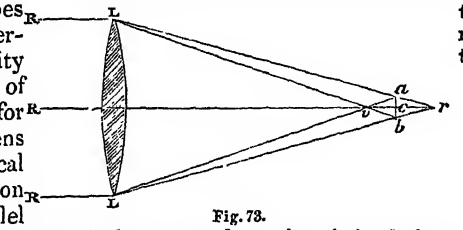

Fig. 73.

In the circle of diffusion *ab* the light becomes very faint towards *a* and *b*, and very intense in the centre *c*, so that there is formed at *c* a sort of general focus indistinct and coloured. Every part of an object, therefore, will have its image, formed in the foci of such a lens, similarly indistinct and similarly coloured, and hence we see the reason why refracting telescopes had such great imperfections that it was necessary to make them of enormous length, in order to obtain a sufficient magnifying power.

From these causes, Sir Isaac Newton despaired of the improvement of refracting telescopes, and set himself at an early period of his life to execute reflecting telescopes. His successors, however, Mr Hall and Mr Dollond, studied the subject of refraction as produced by prisms made of different substances, and found, as we have already fully stated in our history of Optics, that Sir Isaac Newton was mistaken in supposing that all refracting media gave spectra, or separated the colours of white light, in the same proportion as their refractive powers, and that different bodies had different dispersive powers, as well as different refractive ones.[3] This grand discovery we shall now proceed to explain.

Sect. II.—On the different Dispersive Powers of Bodies.

Dispersion of light.

The term *dispersion* has been employed to denote the separation of the different rays of white light into that divergent beam which constitutes the prismatic spectrum, the differently coloured rays having been dispersed or scattered by their different refrangibility. Sir Isaac Newton believed that all bodies whatever, whether *water*, or *crown* or *plate* or *flint glass*, dispersed light in an equal degree,

[1] See sect. v.

[2] These results are taken from his coloured figure of the spectrum.

[3] See the article Achromatic Glasses, vol. ii.

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provided the mean refraction, that is, the refraction of the mean or middle ray of the spectrum (the green ray, viz.), of these bodies was equal; or, in other words, that the dispersion, or the angle formed by the extreme red and the extreme violet ray was in different bodies proportional to the mean refraction.

As Sir Isaac Newton submitted to experiment a number of fluid substances, in the form of prisms, it is, perhaps, one of the most remarkable oversights in the history of science, that he did not think of comparing the length of the spectra which they formed; and it is equally strange that for more than a century he, and all his successors, should never have thought of forming the spectrum from any other luminous body less in diameter than the sun, or even from any luminous line of small breadth. The consequence of these oversights was, that the most important discoveries relative to light, and to optical instruments, were reserved for another age.

In our *History of Optics*, and in the article ACHROMATIC GLASSES, we have given a detailed history of the successive labours of Hall, Dollond, Euler, and others, by which the achromatic telescope was invented and perfected.

If we perform the experiment shown in fig. 70, with two prisms, the one of *flint*, and the other of *crown* glass, and measure in each the length of the spectrum PT, or rather the angles which the violet and the red rays PA, TA make with each other, and the angle which the mean *green* ray forms with the direction of the white beam SY, this last angle will be the mean refraction of the prism, and the first the angular dispersion. We shall then find, that while in crown-glass the quotient obtained by dividing the greater by the lesser angle, or the part of the mean refraction to which the dispersion is equal, will be seventeen hundredths ($\frac{17}{100}$), while in flint-glass it will be thirty hundredths ($\frac{30}{100}$), this number varying with the nature of the glass.

This result may be exhibited to the eye by placing behind a prism of crown-glass C, another of flint-glass F, of such an angle as not to produce any deviation by refraction, the angle of deviation of the green ray produced by the *crown-glass* prism C, being compensated by an equal

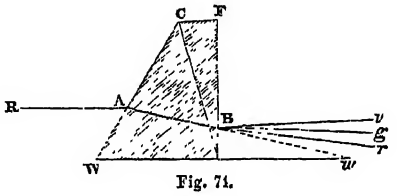

Fig. 74.

and opposite deviation produced by the *flint-glass* prism F; that is, the *green* ray B*g* will emerge parallel to the incident ray RA. When this has been effected, it will be seen that there is still a spectrum *rv*, which will colour the edges of any object which is viewed through the prism, and in which the colours will have the same position as if they had been produced by a small flint-glass prism placed in the same manner as the flint-glass prism F.

If we now take two prisms, one of *crown* and the other of *flint* glass, of such angles that all objects seen through them are colourless, or that a ray of light B*g*, when refracted by them (as in fig. 74), shall be white, it will be found that the white pencil B*w* will be refracted towards the base of the crown-glass prism, the flint-glass having corrected the colour produced by the crown-glass one, but still left a considerable balance of refraction produced by the latter.

Hence it is manifest that the *colours* produced by a convex lens of *crown*-glass, as shown in fig. 73, may be corrected by a concave lens of *flint*-glass, while the rays produced by the unbalanced refraction of the convex glass are still converged to a focus. Such a combination of lenses is called an *achromatic object-glass*, and a telescope with such an object-glass is called an *achromatic telescope*. Chromatics

Nothing is easier than to determine by experiment, when we have obtained good glass for the construction of these lenses, the proper radii to which they should be ground in order to correct the aberration of colour; but it may be readily shown that *the aberration of colour produced by a convex lens of crown-glass will be corrected by a concave lens of flint-glass, provided the focal lengths of the two lenses are proportional to their dispersive power.* Thus, in fig. 75, if LL is a convex lens of crown-glass, whose focus

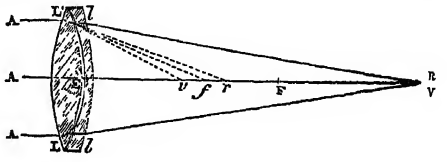

Fig. 75.

for green rays is at *f*, and for violet and red rays at *v* and *r*, and if F is the virtual focus of a concave lens *ll* of flint-glass, for the mean green ray, then parallel rays A, A, A will be refracted to a single focus at RV, where the violet and red rays will be united, provided the focal length of *ll*, viz., EF, is to E*f*, the focal length of LL, as 0·068, the dispersive power of *flint*-glass, is to 0·033, the dispersive power of *crown*-glass.

The dispersive powers of various glasses, and of some fluids, had been measured with considerable care, in reference to the improvement of the telescope, but no attempt was made to investigate it as a branch of physics, exhibiting new and interesting properties of transparent bodies. Dr Wollaston set the example of beginning this inquiry, and he determined in a very general manner the dispersive qualities of thirty-three substances, which he arranged in the order of their dispersive powers, without giving any numerical estimate of their value. In this state of the subject Sir David Brewster, by a new method of measuring dispersive powers, which presented considerable facility of observation, made a very extensive series of experiments on the subject, which, in a physical point of view, presented several curious results. In laying the following table of his observations before our readers, we must warn them that they were made often with the most imperfect specimens of the minerals and fluid substances, from the difficulty of getting any other, and that they were intended only to indicate the general properties of bodies in dispersing light. The want of fixed points in the spectrum in reference to which the measures could be taken, rendered it necessary to use the extreme points, which varied with the intensity of the light employed, and with the absorbing action of the bodies themselves, when they happened to be coloured or imperfectly transparent. The discovery of the fixed lines, and their use in measuring dispersive powers, introduced by Fraunhofer, has given a new impetus to this subject; and when it is practicable to obtain good prisms of the substance under examination, no other method should be adopted. This, however, is very difficult, and in general impossible, especially in saline substances, minerals, and gems, which are never used in combination with glass, or with one another, to produce achromatic combinations. The same remark is applicable to fluids, with very few exceptions. Dispersive powers of bodies.

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Table of the Dispersive Powers of various Solid and Fluid Bodies.

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Names of Substances.	Part of the whole refraction to which the dispersion is equal.	Dispersive power.	Names of Substances.	Part of the whole refraction to which the dispersion is equal.	Dispersive power.	Names of Substances.	Part of the whole refraction to which the dispersion is equal.	Dispersive power.
Chromate of lead (greatest refraction) estimated at	0·770	0·400	Oil of juniper	0·022	0·047	Gum arabic	0·018	0·036
			Oil of chamomyle	0·021	0·046	Sugar, after being melted and cooled	0·020	0·036
Chromate of lead (greatest refraction) must exceed	0·570	0·296	Gum juniper	0·025	0·046	Jelly-fish, body of (*Medusa æquorea*)	0 013	0·035
			Carbonate of strontites (greatest refraction)	0·032	0·046	Water	0·012	0·035
Realgar, a different kind, melted	0·394	0·267	Oil of brick	0·021	0·046	Aqueous humour of a haddock's eye	0 012	0·035
			Flint-glass, Boscovich's lowest	...	0·0457	Vitreous humour of ditto	0·012	0·035
Chromate of lead (least refraction)	0·388	0·262	Nitric acid	0·019	0·045			
Realgar, melted	0·374	0·255	Oil of lavender	0·021	0·045	Citric acid	0 019	0·035
Oil of cassia	0·089	0·139	Balsam of sulphur	0·023	0·045	Rubellite	0·027	0·035
Sulphur, after fusion	0·149	0·130	Tortoise shell	0·027	0·045	Leucite	0·018	0·035
Phosphorus	0·156	0·128	Horn	0·025	0·045	Epidote	0·024	0·035
Sulphuret of carbon	0·077	0·115	Canada balsam	0·024	0·045	Common glass, Boscovich's highest	...	0·0346
Balsam of Tolu	0·065	0·103	Oil of marjoram	0·022	0·045			
Balsam of Peru	0·058	0·093	Gum olibanum	0·024	0·045	Glass of borax	0·018	0·034
			Nitrous acid	0·018	0·044	Garnet	0·027	0·034
Carbonate of lead (greatest refraction)	+0·091	+0 091	Cajeput oil	0·021	0·044	Pyrope	0·026	0·033
			Oil of hyssop	0·022	0·044	Chrysolite	0·022	0·033
Barbadoes aloes	0·058	0·085	Oil of rhodium	0·022	0·044	Crown-glass	0·018	0·033
Essential oil of bitter almonds	0·048	0·079	Pink-coloured glass	0·025	0·044	Common glass, Boscovich's lowest	...	0·033
			Oil of savine	0·021	0·044			
Oil of anise seeds	0·044	0·077	Oil of poppy	0·020	0·044	Oil of ambergris	0·012	0·032
Acetate of lead, melted	0·040	0 069	Zircon (greatest refr.)	0·045	0·044	Oil of wine	0·012	0·032
Balsam of styrax	0·039	0·067	Muriatic acid	0·016	0·043	Phosphoric acid, solid prism, yellow	0·017	0·032
Guiacum	0·041	0·066	Gum copal	0·024	0·043			
Carbonate of lead (least refraction)	0·056	0 063	Nut oil	0·022	0·043	Glass of phosphorus, white	0·017	0·032
			Burgundy pitch	0·024	0·043			
Oil of cummin	0·033	0·065	Oil of turpentine	0·020	0·042	Plate-glass	0·017	0·032
Essential oil of tobacco	0·035	0·064	Oil of rosemary	0·020	0·042	Sulphuric acid	0·014	0·031
Gum ammoniac	0·037	0·063	Feldspar	0·022	0·042	Tartaric acid	0·016	0·030
Oil of Barbadoes tar	0·032	0·062	Glue	0·022	0·041	Nitre (least refraction)	0·009	0·0304
Oil of cloves	0·033	0·062	Balsam of capivi	0·021	0·041	Borax	0·014	0·030
Green-coloured glass	0·037	0·061	Amber	0·023	0·041	Axinite	0·022	0·030
Sulphate of lead	0·056	0·060	Oil of nutmeg	0·021	0·041	Alcohol	0·011	0·029
Deep red glass	0·044	0·060	Stilbite	0·021	0·041	Sulphate of barytes	0·011	0·029
Oil of sassafras	0·832	0 060	Oil of peppermint	0·019	0·040	Tourmaline	0·019	0·028
Opal-coloured glass	0·038	0·060	Spinelle ruby	0·031	0·040	Phosphoric acid, fluid	0·012	0·0283
Muriate of antimony (refr. pr. 1·598)	0·036	0·059	Calcareous spar (greatest refraction)	0·027	0·040	Carbonate of barytes (least refraction)[1]	0·015	0·0285
						Malic acid	0·011	0·0282
Rosin	0·032	0·057						
Oil of sweet fennel seeds	0·028	0·055	Oil of rape-seed	0·019	0·040	Carbonate of strontites (least refraction)	0·015	0 027
			Bottle-glass	0·023	0·040			
Oil of spearmint	0·026	0·054	Tartrate of potash and soda	0·020	0·039			
Orange-coloured glass	0·042	0·053				Crown-glass, Leith, Robison	...	0·033
Rock-salt	0·029	0·053	Carbonate of potash (greatest refraction)	0·013	0·039			
Flint-glass, Boscovich's highest	...	0·0527				Rock-crystal	0·014	0·026
						Emerald	0·015	0·026
Caoutchouc	0·028	0·052	Gum elemi	0·021	0·039	Borax-glass, 1 bor. 2 silex	0·014	0·026
Oil of pimento	0·026	0·052	Sulphate of iron	0·019	0·039			
Flint-glass	0·032	0·052	Diamond	0·056	0·038	Calcareous spar (least refraction)	0·016	0·026
Deep purple glass	0·031	0·051	Oil of olives	0·018	0·038			
Oil of angelica	0·025	0·051	Gum mastich	0·022	0·038	Blue sapphire	0·021	0·026
Oil of thyme	0·024	0·050	White of an egg	0·013	0·037	Bluish topaz, from Cairngorm	0·016	0·025
Oil of fenugreek	0·024	0·050	Oil of rhue	0·016	0·037			
Oil of wormwood	0·022	0·049	Gum myrrh	0·020	0·037	Chrysoberyl	0·019	0·025
Oil of pennyroyal	0·024	0·049	Beryl	0·022	0·037	Blue topaz, from Aberdeenshire	0·016	0·024
Oil of caraway seeds	0·024	0·049	Obsidian	0·018	0·037			
Oil of dill seeds	0·023	0·049	Ether	0·012	0·037	Sulphate of strontites	0 015	0·0 24
Oil of bergamot	0·023	0·049	Selenite	0·020	0·037	Carbonate of potash (least refraction)	0·0088	0·0233
Flint-glass	0·029	0·048	Alum	0·017	0·036			
Chio turpentine	0·028	0·048	Castor oil	0·018	0·036	Prussic acid	0·008	0·0227
Gum thus	0·028	0·048	Sulphate of copper	0·019	0·036	Fluor spar	0·010	0·022
Oil of lemon	0·023	0·048	Crown-glass, very green	0·020	0·036	Cryolite	0·007	0·022
Flint-glass	0 028	0·048						

The following measures of the dispersive powers of several varieties of glass were taken by Sir John Herschel, by a method which gave him nearly the extreme rays of the spectrum, namely, by viewing the spectrum through a dark blue glass, which stops the *green*, *yellow*, and most refrangible *red* rays, and therefore allows the extreme rays of the spectrum to be seen,—rays which the eye does not recognise in any of the ordinary lights which are used in

[1] The dispersive power of the other image is considerably greater than this. See *Edin. Trans.*, vol. vii., p. 289.

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optical instruments. If we condense the sun's light, as we have done, in order to render visible rays at the extremities of the spectrum that have not been recognised, we should obtain dispersive powers still higher than those given by Sir John Herschel. By determining, however, the extremities of the spectrum seen by the ordinary light of the sky, it would be easy to accommodate all measures of dispersive power taken in such a light to those taken in the light used by Sir John Herschel, or in the more condensed and consequently elongated spectrum above referred to. In order that the measures in the following tables may be correct, it is necessary that they should all have been taken when the sun had the same altitude; because it is quite certain that the violet part of the spectrum diminishes in length very rapidly as the sun approaches the horizon, and some change also takes place at the red extremity.

Dispersive Powers of different kinds of Glass.

Names of Substances.	Part of the whole refraction to which the dispersion is equal.	Dispersive power.
Flint-glass	0·03849	0·06404
Ditto	0·03705	0·06409
Ditto	0·03734	0·06386
Ditto, heavy	0·03951	0·06555
Ditto	0·03747	0·06409
Crown-glass	0·02139	0·04063
Ditto, a different kind	0·02494	0·04704
Plate-glass	0·02616	0·05090

Sir John Herschel justly remarks, that it ought not to excite surprise that the dispersions deduced by this method should considerably exceed all former estimates.[1] Chromatics

In the preceding table of dispersive powers we have given two columns of numerical results, the first column containing the part of the whole refraction, or angle of deviation to which the angle of dispersion is equal, and the other the dispersive power itself. The first column is obviously not a measure of the dispersive power, because, if the dispersion in that column is $\frac{1}{20}$th part of a low refraction in one body, and the $\frac{1}{20}$th part of a high refraction in another body of great refractive power, the dispersive power of the latter must be smaller than that of the former, in the inverse ratio of the index of refraction of the two bodies minus unity. Hence the numbers in the second column, the dispersive powers, are obtained by dividing the first column by the index of refraction minus one. Explanation of the tables.

If we wish to have the intrinsic or *absolute* dispersive powers of bodies, in reference to the action of their ultimate molecules, on the theory of emission, and on the supposition, as Sir John Herschel has remarked, in reference to absolute refractive powers, *of the ultimate atoms of all bodies being equally heavy*, we must divide the numbers in the second column of the preceding table by the specific gravities or densities of the bodies. In this way we have computed the results in the following table, containing the substances principally that exercise an extreme action in the dispersion of light. Absolute dispersive power.

Table of Absolute Dispersive Powers.

Names of Substances.	Specific gravities used.	Absolute dispersive power.	Names of Substances.	Specific gravities used.	Absolute dispersive power.
Sulphate of barytes	4·48	0·00602	Water	1·00	0·035
Ditto strontites	3·95	0·00607	Amber	1·04	0·0400
Carbonate of barytes	3·70	0·0063	Oil of olives	0·913	0·0415
Sapphire	3·50	0·0066	Oil of turpentine	0·87	0·0483
Chryso-beryl	3·93	0·00675	Sulphur, fused	2·00	0·065
Topaz	3·50	0·00685	Realgar	3·50	0·0728
Fluor spar	3·17	0·0069	Phosphorus	1·75	0·0731
Cryolite	2·95	0·0074	Oil of anise seeds	0·987	0·078
Diamond	3·50	0·0109	Bi-sulphuret of carbon	1·27	0·081
Plate-glass	2·76	0·0112	Oil of cassia	1·044	0·131
Rock-salt	2·143	0·0250			

These results present us with several views of considerable interest. The salts of barytes have, in reference to their density, the least dispersive power of all bodies, and the next in order are the gems, including even diamond, which occupies so different a place in our table of absolute refractive powers. The inflammable bodies, with the exception of diamond, stand at the head of the table, *oil of cassia* having by far the greatest absolute dispersive power of any body yet examined. That this is owing to the hydrogen which it contains is very probable, and has almost been proved by an experiment by Sir John Herschel, who deprived a portion of this oil of most of its hydrogen by making a stream of chlorine pass through it till it refused to act any farther. By this means he converted the oil into a viscous mass, the dispersive power of which was diminished one-half, while its refractive power had hardly suffered any change. This result leads us to conclude that *hydrogen* has the greatest intrinsic dispersive power of all bodies. *Fluorine* seems to be the element which has nearly the lowest dispersive power.

Double dispersive power.

One of the most interesting results exhibited in the general table of dispersive powers relates to the dispersive powers of doubly-refracting substances. Dr Wollaston had measured the dispersive power of the ordinary ray in calcareous spar, so far at least as to ascertain that it stood above water, and plate and crown glass. Sir David Brewster had been led to measure the dispersion of the extraordinary ray, and found it to be much lower than that of water. He was hence induced to examine the dispersive powers of other doubly-refracting crystals, and was thus led to the result which we have stated.[2] Similar results have been more recently obtained by M. Rudberg and Mr Cooper, without knowing that the subject had been previously investigated.

Sect. III.—On the Irrationality of the Coloured Spaces in the Spectrum, and the Existence of a Secondary Spectrum.

We are indebted, we believe, to M. Clairaut for the discovery of the irrationality of the coloured spaces in the spectrum. He found that when the flint-glass of an achromatic object-glass had its aberration of colour as completely corrected as possible,—that is, when the extreme red and violet rays were accurately united in the same focus,—still there remained a portion of uncorrected colour, which was of a purple or claret colour on one side of the focus, and of a green colour on the other. If prisms had been used Secondary spectrum. Clairaut.

[1] *Edin. Trans.*, vol. ix., p. 458.

[2] See *Phil. Trans.* 1813, p. 107, where this result was first published.

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in place of lenses, and the sun's light transmitted through them in the usual manner, there would have been a small residual spectrum, or *secondary spectrum*, as it has been called, consisting of purple and green light. The Abbé

Boscovich.

Boscovich afterwards observed the same fact, but considered it so extraordinary that he suspected some latent cause of error, and submitted his experiments to the most rigid scrutiny. He at last admitted the irrationality of the coloured spaces in the spectrum as a demonstrated truth, and has shown how three of the colours of the spectrum may be corrected or united in the same focus in achro-

Robison.

matic telescopes. Professor Robison obtained similar results, and gave the name of *outstanding* colours to those which were not united, and which form the secondary spectrum.

Blair.

This subject was more fully investigated by Dr Blair, in his interesting paper on the unequal refrangibility of light,[1] and he has shown that the proportions of the coloured spaces vary with the substance of the opposing prisms, so that a complete correction of colour cannot possibly be effected by two media of different dispersive powers. Hence Dr Blair was led to examine the nature of the dispersive action of different media, and by the most ingenious devices succeeded in producing fluid object-glasses in which the *aberration of colour was completely corrected.* The telescopes which he made on this principle were so extraordinary, that Professor Robison assures us that one of them, FIFTEEN inches in focal length, *equalled in all respects, if it did not surpass, the best of Dollond's* FORTY-TWO inches long.

Wollaston.

Under these circumstances, the scientific world was surprised at the following statement published by Dr Wollaston in the *Phil. Trans.* for 1803 :—"Since the proportions of these colours *have been* supposed by Dr Blair to vary according to the medium by which they are produced, I have compared with this appearance the coloured images caused by prismatic vessels containing substances supposed by him to differ most in this respect, such as strong but colourless nitric acid, rectified oil of turpentine, very pale oil of sassafras, Canada balsam, also nearly colourless. With each of these I have found the same arrangement of these four colours, and in similar positions of the prisms, as nearly as I could judge, the same proportions of them." Dr Blair was surprised that Dr Wollaston should have used such a coarse method of determining a point that required delicate observations, especially with the substances above mentioned; and he remarked to the writer of this article, that if Dr Wollaston would only make use of lenses, he would see his mistake after a single observation.

There is no doubt, however, that the secondary spectrum can be made very visible by prisms, and if we use a prism of oil of cassia to correct the colour produced by another of sulphuric acid, we shall have a striking ocular proof of the existence of a large secondary spectrum.

The phenomena of a secondary spectrum will be understood from fig. 76, where RR is a ray passing through an aperture in the window-shutter SS, and refracted by a prism P in the direction PM, so as to form the spectrum AB on the wall—PA being the extreme violet ray, PM the mean ray, and PB the extreme red. The spectrum will consist of four palpable colours,—*red, green, blue, and violet;* and if the prism is one of *crown-glass*, the mean ray PMN which bisects the spectrum will be at the boundary of the blue and green spaces. If we were to take a prism of flint-glass with a much less refracting angle, and form a spectrum CD of the same length as AB, and at the same distance from the prism, the line *mn* which marks the boundary of the blue and green spaces will no longer be the mean ray of the spectrum, but will be decidedly nearer the

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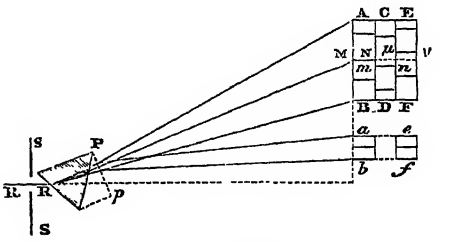

Fig. 76.

red extremity D. The least refrangible half of the spectrum has therefore been more contracted, and the most refrangible half more expanded than in the crown-glass spectrum. If we now take a prism of sulphate of barytes or fluor spar, capable of forming a third spectrum EF of the same length as the other two, the boundary of the blue and green spaces will now be at $\mu\nu$, nearer the violet than the red extremity of the spectrum, and the least refrangible half of this spectrum will be more *expanded*, and the most refrangible half more *contracted*, than in the crown-glass spectrum.

"If a spectrum," says Sir David Brewster,[2] "formed by flint-glass, had its coloured spaces exactly of the same dimensions with those of an equal spectrum formed by crown-glass, any object, such as a window-bar lying parallel to the common section of the refracting planes of the two prisms, should appear perfectly colourless when seen through the combined prisms. But if the coloured spaces in the two spectra are not proportional, as shown in fig. 76, but are *irrational*, then the window-bar cannot be wholly free from colour, for though the extreme red and violet rays of both the spectra are united, yet the intermediate colours are not rendered coincident. In the spectrum AB, formed by the crown-glass, the first green ray MN, which is here the mean ray, is obviously more refracted than the first green ray *mn* in the spectrum CD formed by the flint-glass, and therefore the flint-glass will not be able to refract the green ray so as to unite it with the red and violet. Hence the green ray will, as it were, be left behind, while the red and violet rays are rendered coincident. Thus, if a prism *p* of flint-glass is placed behind a crown-glass prism P, so as exactly to correct its dispersion, the spectrum AB will be reduced to a secondary spectrum *ab*, the upper half of which is *green*, which is left behind, and the lower half is of a *claret* colour, formed by the union of the red and violet rays. If the bar of a window had been examined through the combined prism P*p*, the upper side of it would have been tinged with green, and the lower side of it with a claret-coloured fringe.

"By comparing, in a similar manner, the spectrum EF, formed by fluor spar, with the spectrum AB, formed by crown-glass, it will be found that the fluor spar, having a greater action than the crown-glass upon the green ray, will carry it beyond the place of the united red and violet, and will form a secondary spectrum *ef*, the lower half of which is *green*, and the upper half of a *claret* colour, arising from the union of the red and violet light. If the bar of a window were viewed through the combined prisms of crown-glass and rock-crystal, it would be tinged with green on its lower side, and with a claret-coloured fringe on its upper side.

"When a horizontal window-bar, therefore, is seen through any two prisms which correct each other's dispersion, without uniting all the colours, the green fringe will always be

[1] *Edin. Trans.*, vol. iii., p. 3.

[2] *Treatise on New Philosophical Instruments*, 1813, p. 356.

Chromatics

on the same side of the bar with the vertex of the prism which has the least action upon the green light, or which *contracts* the red and green rays, and *expands* the blue and violet ones; that is, if the vertex of the flint-glass prism is pointing downwards, the uncorrected green fringe will be on the lower side of the bar. By observing, therefore, the position of the green fringe, we can immediately ascertain which of the two prisms has the greatest action upon the green light.

The following table contains the result of a numerous series of observations made by Sir David Brewster on the secondary spectra of different bodies, the substances being arranged inversely according to their action upon green light. The bodies at the top of the table form spectra in which the red and green spaces are most contracted, and the blue and violet ones most expanded. The relative position of some of the substances, particularly the essential oils, is quite empirical; but by a reference to the original experiments, it will be seen whether or not the relative action of any two bodies has been determined.[1]

Table of Transparent Bodies arranged inversely according to their Action upon Green Light.

1. Oil of cassia.
   Sulphur.
   Sulphuret of carbon.
   Balsam of Tolu.
5. Carbonate of lead.
   Essen. oil of bitter almonds.
   Oil of anise-seeds.
   Oil of cummin.
   Oil of sassafras.
10. Oil of amber.
    Acetate of lead melted.
    Opal-coloured glass.
    Orange-coloured glass.
    Red-coloured glass.
15. Oil of sweet fennel seeds.
    Oil of cloves.
    Muriate of antimony.
    Oil of lavender.
    Canada balsam.
20. Oil of turpentine.
    Oil of sage.
    Oil of pennyroyal.
    Oil of poppy.
    Oil of hyssop.
25. Oil of spearmint.
    Amber.
    Oil of lemon.
    Oil of caraway-seeds.
    Oil of nutmegs.
30. Oil of thyme.
    Oil of peppermint.
    Oil of bergamot.
    Oil of marjoram.
    Oil of wormwood.
35. Oil of dill seeds.
    Oil of chamomile.
    Castor-oil.
    Gum copal.
    Rosin.
40. Diamond.
    Nitrate of potash.
    Oil of beech-nut.
    Oil of rue.
    Oil of savin.
45. Nut-oil.
    Balsam of capivi.
    Oil of fenugreek.
    Oil of rosemary.
    Oil of rhodium.
50. Flint-glass.
    Zircon.
    Oil of olives.
    Oil of rape-seed.
    Oil of spermaceti.
55. Oil of juniper.
    Oil of ambergris.
    Calcareous spar.
    Rock-salt.
    Gum juniper.
60. Tartrate of potash and soda.
    Oil of almonds.
    Crown-glass.
    Gum-arabic.
    Alcohol.
65. Ether.
    Borax, glass of.
    Borax.
    Tourmaline.
    Leucite.
70. Selenite.
    Beryl.
    Topaz, blue.
    Fluor spar.
    Citric acid.
75. Malic acid.
    Acetic acid.
    Nitrous acid.
    Muriatic acid.
    Prussic acid.
80. Nitric acid.
    Rock-crystal.
    White of an egg.
    Ice.
    Water.
85. Super-sulphuretted hydrogen.
    Phosphorous acid.
    Sulphurous acid.
    Phosphoric acid.
89. Sulphuric Acid.

Dr Blair's aplanatic telescope.

Finding it impossible to obtain any highly dispersing medium which should refract the rays of the spectrum in the same manner as crown-glass, Dr Blair thought of employing this very imperfection in obtaining a perfect correction of colour. As the green rays remained the outstanding ones, or were not united in the same focus with the red and violet, he considered that if an achromatic *concave* lens should refract the outstanding green more strongly than the united red and violet, while an achromatic *convex* lens should also refract the outstanding green more strongly than the united red and violet, then two such achromatic lenses combined might unite the outstanding green with the red and violet, and thus effect a perfect union of all the colours. Hence he took the combination shown in fig. 77, for a concave lens, composed of a concave lens *ab*, of crown-glass, and a convex lens *cd* of a fluid which had its dispersive power of such a character as to unite the *red* and *violet* rays as stated in the figures, and leave the green outstanding and *most refracted*. He then made an achromatic *convex* lens, fig. 78, composed of a convex lens *hg* of an essential oil, the same as that in *cd*, which disperses the rays in a lesser degree, and of a concave lens *efgh* of an essential oil which disperses the rays in a much greater degree. This compound lens has its convexity such as to unite at a convenient distance, rays which diverge from the violet focus of the compound concave lens shown in fig. 77, and therefore its focal length must be much shorter than the other, like the flint lens in a common achromatic. But though the focal lengths of the two compound lenses are thus different, yet, the distance or deviation of the outstanding green from the united red and violet is equal in both.

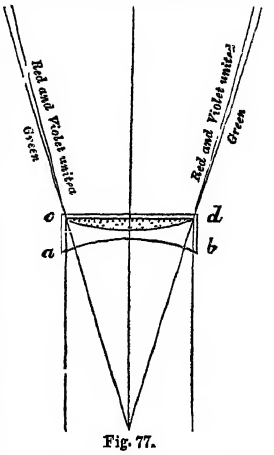

Fig. 77.

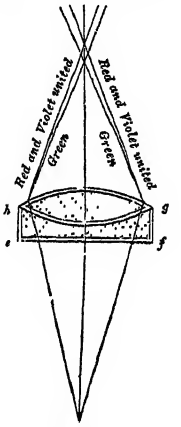

Fig. 78.

When these two compound lenses are placed in contact, as shown in fig. 79, it is manifest that the equal and opposite deviations of the green ray will balance each other, and that this ray will therefore be united with the red and violet, and thus form a pencil exempt from secondary colours. The plates of glass shown by dotted lines at *ef*, *cd*, though necessary when the two compound lenses are separate, as in figs. 77, 78, are of course removed, since the two fluids which they separate, as fig. 79, are the same. Hence the compound object-glass consists of a concave lens of crown-glass *ab*, of a meniscus *ef*, of a fluid, and a convex glass of another fluid, inclosed between two glasses like watch-glasses. Dr Blair found it best in practice to make all the glasses concave meniscuses, in place of having all the concavity in one lens *ab*.

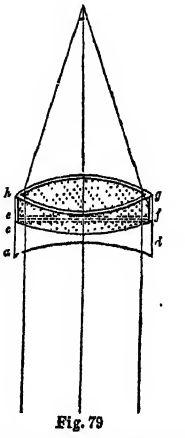

Fig. 79

In continuing his experiments, Dr Blair happened to try the muriatic acid mixed with a metallic solution. He found it best to make his compound convex lens, as shown in fig. 78, of crown-glass and that fluid, which enabled him to correct the colour of the compound concave in fig. 77, and like-

[1] Brewster's *Treatise on New Philosophical Instruments*, pp. 373–387.

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wise to correct the aberration of figure by a concave which lengthens only by one-third the focal distance of the convex.

When he was trying a compound concave formed only of crown-glass and muriatic acid, he observed that this fluid produced an inverted secondary spectrum, and gave a primary spectrum in which the green rays were among the most refrangible; and hence he was conducted to the idea of forming a compound lens consisting merely of a single concave lens of muriatic acid placed between a plano-convex and a meniscus of crown-glass. In this lens, which he actually constructed and used, he observes *that the rays of different colours were bent from their rectilineal course with the same equality and regularity as in reflection.*[1]

Fig. 80.

In such telescopes, Dr Blair found that when the focal length of the object-glass was *nine inches*, the aperture might be increased as far as *three* inches; and in order to distinguish such instruments where the aberration is removed, from *achromatic* ones in which it is only partially removed, he proposed the use of the term *aplanatic*.[2]

Section IV.—On the Tertiary Spectrum, and the Method of Correcting the Aberration of Colour by Prisms and Lenses of the same kind of Glass.

Tertiary spectrum.

The existence of the *tertiary* spectrum was discovered experimentally by Sir David Brewster, who deduced it also from the constant ratio of the sines. It is produced when the dispersion of a prism of any substance is corrected by another prism of the same substance with a different refracting angle. An irrationality takes place in the coloured spaces, which prevents the correction of colour from being complete. The residuary spectrum was therefore called the *tertiary* spectrum, merely to distinguish it from the *secondary* one, which is produced by the specific quality in the refracting media, which act in opposition to each other.

In examining the phenomena of this new spectrum, Sir David Brewster was led to a very paradoxical method of exhibiting it. Having formed a prism of oil of cassia, with a large refracting angle, and viewing through it the broadest horizontal bar of a window, so that the edges of the bar were free of all colours, he inclined the prism so as to make the bar exhibit at its edges the prismatic colours, as shown in fig. 81, where the edges *b*M and *e*N had spectra *ba*M, *ef*N, consisting of the usual *red* and *yellow* rays, while the edges *e*M, *b*N had spectra *ed*M, *bc*N composed of the usual blue and violet rays. These spectra increased from *b* and *e* towards M and N, and at the nodes *b*, *e*, where the spectra would have vanished, had each face of the prism received the rays symmetrically, the *tertiary spectrum* was clearly displayed in the form of a *green* and *yellow* fringe.

Fig. 81.

In order to produce refraction without colour by two prisms of the same kind of glass, they may be combined, as in fig. 82, where a ray of light R incident on the first prism AB is refracted to the axis MF at F. The prism AB has a smaller refracting angle than CD, and is placed in an oblique position, so that its dispersion is increased in a greater ratio than its refraction, for the purpose of correcting the dispersion of CD without balancing its refraction; the prism CD having a position in which its refraction and dispersion are a minimum. The ray R will therefore converge colourless, and meet the axis at F.

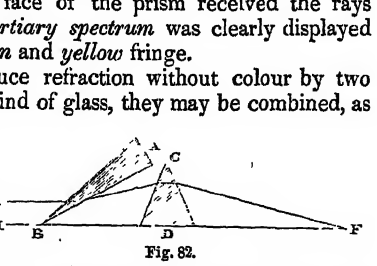
Fig. 82.

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If the prisms have the same refracting angle, and are placed in the position shown in fig. 83, the ray R will emerge colourless in the direction *mr*. This combination of prisms,

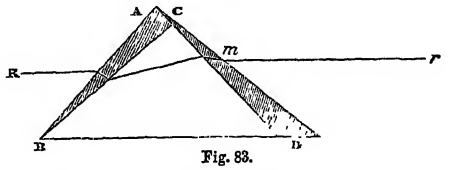
Fig. 83.

as well as that in fig. 82, has the property of expanding all objects viewed through them, in a vertical plane passing through their sections BACD; that is, of *magnifying them in one plane*. Hence, if we place another similar pair of prisms horizontally, this pair also will magnify objects in a horizontal plane, and by combining these two pair of prisms, we obtain an instrument which will expand or magnify objects in all directions.

This instrument was first constructed by Sir David Brewster in 1812, under the name of a *teinoscope*, for altering the proportions of objects in plans and drawings, by expanding them differently in rectangular directions;[3] and there is reason to think that Dr Blair was acquainted with this method of magnifying objects by prisms. Mr Archibald Blair some years ago put into Sir David Brewster's hands an instrument of this kind, composed of four prisms, which had been executed by his father, but the date of its construction he had no means of discovering. There cannot, therefore, be the shadow of a doubt that both the principles and the invention of an instrument for magnifying objects by means of prisms, were known and published in Scotland long before the celebrated M. Amici of Florence brought forward a contrivance of the same kind. That M. Amici's invention was an independent one will not be questioned.

As we conceive that a telescope of this kind may have many useful applications, we have given in the annexed figure a sketch of the instrument as actually fitted up for use. It consists of two prisms, AB, AC of the same kind of glass, and having a small refracting angle. Their common line of junction at A is horizontal, and their planes of refraction vertical. Other two similar prisms DE, EF, are placed transversely, their common line of junction at E being vertical, and their planes of refraction horizontal. An object M, therefore, seen through the prisms in the direction OM, by an eye placed at O, will be magnified three, four, or five times, or more, according to the inclination and angles of the prisms. It is expanded or stretched out in a horizontal plane by the two first prisms ED, EF, and then expanded and stretched out in a vertical plane by the other two prisms AB, CD.

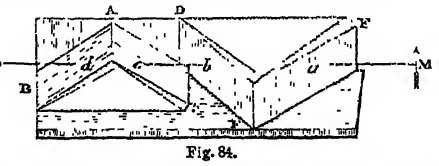
Fig. 84.

If we use homogeneous light, we may construct the instrument with only two prisms, as there is no necessity for correcting the colour with a second prism. For solar observations, the two prisms will constitute a telescope, a darkening glass being used as in other instruments. It will be thus equally useful for viewing the lines in the spectrum, where homogeneous light is necessarily used; and by placing two, three, or four instruments in the same tube, we

[1] *Edin. Trans.*, vol. iii., p. 53. [2] Ibid. [3] *Edin. Phil. Jour.*, vol. vi., p. 334, April 1822.

Prismatic Spectrum.

may obtain any magnifying power we desire. The length of the instrument which we have drawn is only *two inches and three-quarters.*

Sect. V.—On the Optical Phenomena of the Spectrum.

Phenomena of the spectrum.

Although the discovery of the principle, and the actual construction of *achromatic* and *aplanatic* telescopes had directed the attention of many observers to the nature of the prismatic spectrum, yet, with the exception of its varying length in different bodies, and the continuity of its coloured spaces, no attempt was made to question the general account of its phenomena given by Sir Isaac Newton.

Owing to his having used the diameter of the sun as the body from which his spectrum was formed, and to the difficulty of procuring in his day good prisms of glass, Sir Isaac never obtained anything like pure homogeneous light, and was therefore unable to determine the exact boundaries of the coloured spaces. Had the spectrum been observed in the same manner on the planet Mercury and on Saturn, the spectrum produced by the same prism would have been very different. On Mercury the rays would have been less pure and homogeneous than that observed on our earth, and the mean refrangible rays of a different colour; while on Saturn the colours would have been more pure and homogeneous.

1. *Discoveries of Dr Wollaston.*

Discoveries of Dr Wollaston.

The first person, in so far as we know, who proposed to form the spectrum by using *a very narrow pencil of light* in place of the sun, was Dr Wollaston, to whom we owe many most valuable observations on the subject.

"I cannot," says he, "conclude these observations on dispersion, without remarking, that the colours into which a beam of white light is separable by refraction, appear to me

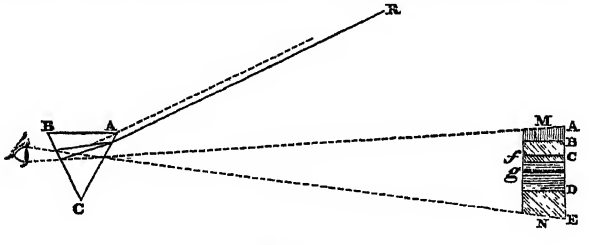

Fig. 85.

Fixed lines in the spectrum.

to be neither seven, as they usually are seen in the rainbow, nor reducible by any means (that I can find) to three, as some persons have conceived; but that by employing a very narrow pencil of light, four primary divisions of the prismatic spectrum may be seen with a degree of distinctness, that I believe has not been described nor observed before. If a beam of daylight be admitted into a dark room by a crevice $\frac{1}{30}$ of an inch broad, and received by the eye at the distance of ten or twelve feet through a prism of flint-glass, *free from veins*, held near the eye, the beam is seen to be separated into the four following colours only, *red, yellowish-green, blue,* and *violet,* in the proportions represented in the figure.

"The line A that bounds the *red* side of the spectrum is somewhat confused, which seems in part owing to the want of power in the eye to converge red light. The line B, between red and green in a certain position of the prism, is perfectly distinct; so also are D, and E, the two limits of violet. But C, the limit of green and blue, is not so clearly marked as the rest; and there are also, on each side of this limit, other distinct dark lines, *f* and *g*, either of which, in an imperfect experiment, might be mistaken for the boundary of these colours. Prismatic Spectrum.

"The position of the prism in which the colours are most clearly divided, is when the incident light makes about equal angles with two of its sides. I then found that the spaces AB,BC,CD,DE, occupied by them, were nearly as the numbers 16, 23, 36, 25." Dr Wollaston adds, that when the inclination of the prism is altered so as to increase the dispersion of the colours, the proportions of them to each other are then also changed, so that the spaces AC and CE, instead of being as before 39 and 61, may be found altered as far as 42 and 58.

The lines which Dr Wollaston has described in the preceding observations, are called the *fixed lines in the spectrum,* and may be considered, as we shall presently have reason to see, as one of the most valuable observations which have been made on this subject. He owed the discovery solely to his having used a *narrower* line of light, and had he employed a still narrower and brighter line, he would have seen many more lines.

In considering Dr Wollaston's observations, and comparing the results with those of Sir Isaac Newton, we must carefully attend to the circumstance, that he used *a beam of daylight,* not one of sunlight, and as this beam emanated from the blue sky, and was light which had been greatly modified by the action of the atmosphere, as we shall soon show, his estimate of the number and nature of the coloured spaces does not in the least affect or invalidate the observations of preceding authors. The sun's light used by Newton had lost many of its rays by the absorptive action of the atmosphere, before it fell upon Dr Wollaston's prism. In consequence of taking it for granted that Dr Wollaston was analysing the same kind of light that Sir Isaac Newton analysed, both he and Dr Young were misled in the interpretation of the phenomena. Speaking of the observations of Newton and his followers, Dr Young says, "The observations were however imperfect, and the analogy was wholly imaginary. Dr Wollaston has determined the division of the coloured image or spectrum in a much more accurate manner than had been done before; by looking through a prism at a narrow line of light, he produces a more effectual separation of the colours than can be obtained by the common method of throwing the sun's image on a wall. The spectrum formed in this manner consists of four colours only, *red, green, blue* and *violet,* which occupy spaces in the proportion of 16, 23, 36, and 25, respectively, making together 100 for the whole length; the red being nearly one-sixth, the green and the violet each about one-fourth, and the blue more than one-third of the length. The colours differ scarcely at all in quality within their respective limits, but they vary in brightness; the greatest intensity of light being in that part of the green which is nearest to the red. A narrow line of *yellow* is generally visible at the limit of the red and green; but its breadth scarcely exceeds that of the aperture by which the light is admitted, and Dr Wollaston attributes it to the mixture of the *red* with the *green* light.[1] There are also several dark lines crossing the spectrum within the blue portion and in its neighbourhood, in which the continuity of the light seems to be interrupted. This distribution of the spectrum Dr Wollaston has found to be the same whatever refracting substance may have been employed for its formation; and he attributes the difference which has sometimes been observed in the proportion, to accidental variations of the obliquity of the rays."[2] Hence Dr Young was led to suppose that the *yellow* line was the accidental union of the

[1] Dr Young has given in his *Elements of Natural Philosophy,* vol. i., p. 786, plate 29, a small coloured drawing of the spectrum as seen by Dr Wollaston and himself, with the *yellow* line. This line has no existence in the true solar spectrum.

[2] *Nat. Phil.,* vol. ii., p. 637.

Prismatic Spectrum.

extremity of the *red* and *green* spaces,—to regard *yellow* as a mixture of *red* and *green* light, and to suppose that the *green space* consisted only of homogeneous green without any mixture of yellow. "In consequence," says he, "of Dr Wollaston's *correction* of the description of the prismatic spectrum compared with these observations, it became necessary to modify the supposition that I advanced in the last Bakerian lecture respecting the proportions of the sympathetic fibres of the retina; *substituting* RED, GREEN, and VIOLET, for RED, YELLOW, and BLUE." In this manner the *yellow* space was struck out of the spectrum on the authority of Dr Wollaston's observations!

2. *Discoveries of Fraunhofer.*

Discoveries of Fraunhofer.

Without knowing anything of the discovery of fixed lines in the skylight by Dr Wollaston, M. Fraunhofer, a celebrated practical optician at Benedictbaiern, near Munich, made a series of the most beautiful discoveries respecting the spectrum, which he published in 1814 and 1815. By making use of prisms of uniform density, and entirely free of veins, and by excluding all extraneous light, and stopping the rays which formed the coloured spaces which he was not examining, he made the important discovery that the

Lines in the spectrum.

solar spectrum was covered with a great number of black lines of different thicknesses parallel to each other, and perpendicular to the length of the spectrum.

All kinds of prisms, fluid or solid, provided they were good, exhibited the same lines, and Fraunhofer found that these lines had a fixed position in the spectrum, and that they varied with the length of the spectrum, the distance between any two affording a precise measure of the action of the prism on the rays in which these two lines were placed. These lines are darker than the rest of the spectrum, and some of them appear entirely black. The largest lines could scarcely be seen if the aperture exceeded a *minute*, and the finest lines also disappeared entirely when the aperture was 40″. The aperture used by Fraunhofer was nearly one-fiftieth of an inch wide, and 2·88 inches high. The prism was made of flint-glass, and had a refracting angle of nearly 60°, and was placed before the object-glass of the telescope so that the angles of incidence and emergence were equal, or the angle of refraction a *minimum*. This apparatus is shown in fig. 86,

Prismatic Spectrum.

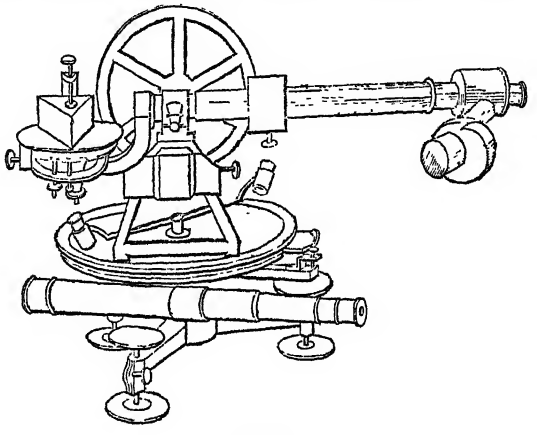

Fig. 86.

where the prism is seen in front of the object-glass of the telescope of a repeating theodolite resting on a horizontal plane with a steel axis, round which it moves.

When the prism was turned round, so as to increase the angle of incidence, the lines disappeared, and the same took place when the angle of incidence was diminished. But the lines reappeared at a greater incidence by shortening, and at a smaller incidence by lengthening the telescope.

The *solar prismatic spectrum*, as seen by Fraunhofer, is represented in fig. 87, which has been abridged, and many

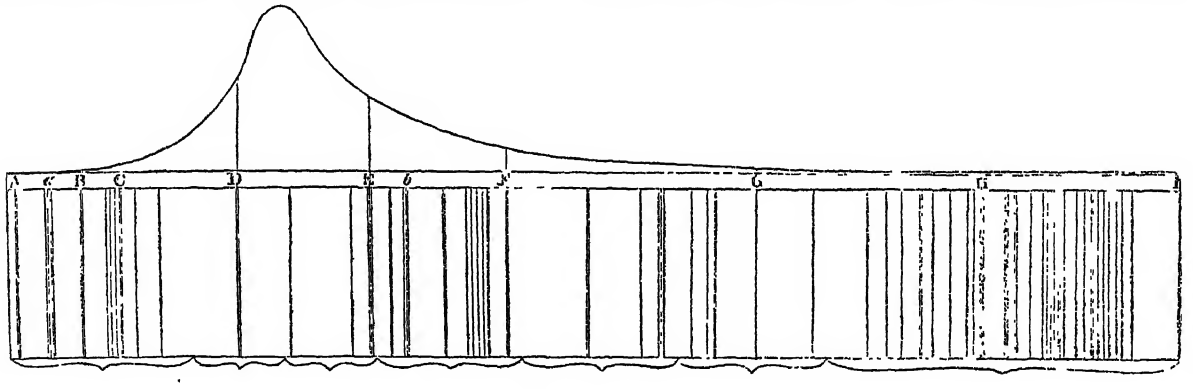

Fig. 87.

of the lines necessarily omitted, Fraunhofer himself having been obliged to leave them out of his map. At the line A the *red* space nearly terminates, and the violet space at I; but when the light of an illuminated cloud fell upon the aperture in the prism, the spectrum appeared to terminate on one side at B, and on the other between G and H. At A there is a distinct and well-defined line, the boundary of the red space being a little beyond it. "At *a* there is a mass of lines, forming together a band darker than the adjacent parts. The line at B is very distinct, and of a considerable thickness. From B to C may be reckoned nine very delicate and well-defined lines. The line at C is broad, and black like D. Between C and D are found nearly thirty very fine lines, which, however, with the exception of two, cannot be perceived but with a high magnifying power, and with prisms of great dispersion; they are besides well defined. The same is the case with the lines between B and C. The line D consists of two strong lines separated by a bright one. Between D and E we recognise about 84 lines of different sizes. That at E consists of several lines, of which the middle one is the strongest. From E to *b* there are nearly twenty-four lines. At *b* there are three very strong ones, two of which are separated by a fine and clear line. They are among the strongest in the spectrum. The space *b*F contains nearly fifty-two lines, of which F is very strong. Between F and G there are about 185 lines of different sizes. At G many lines are accumulated, several of which are remarkable for their size. From G to H there are nearly 190 different lines. The two bands at H are of a very singular nature. They are both nearly equal, and are formed of several lines, in the middle of which there is one very strong and deep. From H to I they likewise occur in great numbers. Hence it follows that, in the space BH, there are 574 lines. The relative distances of the strongest lines were measured with the theodolite, and placed in the figure from observation. The

Prismatic Spectrum.

faintest lines only were inserted from estimation by the eye." The lines in the solar spectrum which we have thus minutely described after Fraunhofer, are not seen in the spectra formed by any white flame or white light, whether it is generated by ordinary combustion, or produced by the application of intense heat to a solid body. In the flame of a lamp, however, Fraunhofer discovered that there is a double yellow line occupying *exactly* the same place as the double line D, the two black lines of D corresponding with the two luminous ones of the double yellow line in lamp light. Hence it follows that ordinary *white* light, produced in the manner already mentioned, has 590 rays of a definite refrangibility which do not exist in solar light, and hence the black lines have been called *defective rays* or *lines*.

Prismatic Spectrum.

By means of the apparatus shown in fig. 86, Fraunhofer determined in a very accurate manner the distances between the principal fixed lines[1] B, C, D, E, F, G, H, taking those which divided the spectrum most conveniently. The line *b*, for example, would have been better than E for its magnitude and distinctness, but it does not divide the space DF so equally. He repeated these observations with different kinds of flint and crown glass of several fluids, and obtained the results given in the following table:—

Table showing the Distances of the Principal Fixed Lines in the Spectrum in various Media, according to Fraunhofer.

Different Combinations of Refracting Media.	Temp. Fahr.	Specific Gravity.	Angle of the Prism.	Angle of Deviation.	BC	CD	DE	EF	FG	GH
Flint-glass, No. 13	65¾°	3·723	26° 24′ 30″	17° 27′ 8″	3′ 16″	9′ 4″·2	11′ 50″	10′ 33″·9	20′ 23″·9	18′ 18″
Crown-glass, No. 9	63½	2·535	39 20 35	22 38 19	2 44·5	7 23·5	9 14	8 14	15 10	13 18
Water	65¾	1·000	58 5 40	22 36 40	3 24	8 10	9 58	8 38	15 16	12 41·9
Ditto	65¼	1·000	58 5 40	22 36 40	3 12·4	8 10·6	9 57·5	8 30·5	15 15·6	12 46·2
Sol. of potash in water	52¼	1·416	58 5 40	27 45 56	4 2	10 26	12 54	11 12	20 36	17 24
Oil of turpentine	...	0·885	58 5 40	33 20 12	4 56	13 52	18 46·1	16 14	31 8	27 28
Flint-glass, No. 3	...	3·512	27 41 35	17 35 16·6	3 8	8 22	10 46	9 50	19 10	17 10
Ditto No. 30	...	3·695	21 42 15	14 3 9	2 35·6	6 56·8	9 12·6	8 19	16 15·6	14 32·2
Crown-glass, No. 13	...	2·535	43 27 36	25 26 35·4	3 5	8 14·4	10 28·2	9 10	17 14·8	14 48·4
Ditto	...	2·756	42 56 40	26 39 13	3 32·8	9 37·6	12 29·8	11 1·6	20 53·6	18 17·4
Flint-glass, No. 23	...	3·724	60 15 42	49 55 13·2	11 12·6	31 14·8	41 21·4	38 14·8	1° 14 45·2	1° 8 3·6
Ditto, ditto	...	3·724	45 23 14	32 45 12·2	6 26	17 47·8	23 31·8	21 23·8	41 33·4	37 28·8

These valuable data were deduced from measures taken *six* times for each substance; but as the theodolite was only twenty-four feet distant from the window of his dark room, it became necessary to apply a correction to the angle of deviation μ, arising from the distance 4·25 inches of the centre of the prism from the axis of the theodolite. This correction would have been very great for twenty-four feet, and therefore Fraunhofer, to avoid the uncertainty which arises from a great correction, determined the angle μ for the yellow ray of the light of a lamp which has the same refrangibility as D. When the lamp was placed at the distance of 692 feet, the correction of μ for crown-glass and water was only 40″. Hence for the smaller arcs, which were really measured, the corrections were very small, being only 2″·5 for BC, 6″·5 for CD, and 8″ for DE. All the angular distances, therefore, in the preceding table have had this correction applied to them.

M. Fraunhofer then proceeded to determine the index of refraction m for the different fixed lines, and calling σ the angle of incidence, ρ the angle of emergence, ψ the angle of the prism, and m the index of refraction, he obtained,

$$m=\sqrt{\left(\frac{(\sin\rho+\cos\psi\sin\sigma)^2+(\sin\psi\sin\sigma)^2}{\sin\psi}\right)}$$

When the angle of incidence is equal to the angle of emergence, or the angle of deviation a *minimum*, and if μ is the angle of deviation, or that which the emergent ray forms with the incident ray, we have

$$m=\frac{\sin\frac{1}{2}(\mu+\psi)}{\sin\frac{1}{2}\psi}.$$

When the dispersive power of the body under examination is very great, the value of the index of refraction m given by this last formula will not be rigorously correct, as the equality of the angles of incidence and emergence can only take place for one ray. Fraunhofer, therefore, measured the distances BC, CD, when the distance of the two lines B and C, C and D was the smallest, which takes place when the ray or line which bisects these spaces has its angle of incidence and emergence equal. When the substances have a less dispersive power, or the prisms a smaller angle, the same care is not necessary to obtain this degree of accuracy. If we then call Em the index of refraction for the ray E, we have

$$\mathrm{E}m=\frac{\sin\frac{1}{2}(\mu+\psi+\mathrm{DE})}{\sin\frac{1}{2}\psi};$$

and for the ray F,

$$\mathrm{F}m=\frac{\sin\frac{1}{2}(\mu+\psi+\mathrm{DE}+\mathrm{EF})}{\sin\frac{1}{2}\psi}.$$

In this way Fraunhofer obtained the following indices of refraction for the different solids and fluids formerly used:—

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[1] The reader will be desirous of knowing which of these principal lines were discovered by Dr Wollaston. The following attempt to do this is given by Sir David Brewster in his "Report on Optics," published in the *Proceedings of the British Association*, vol. i., p. 320, note 2:—"In the spectrum formed by a narrow beam of daylight, Dr Wollaston had, previously to the year 1802, discovered *seven* lines, which he has designated by the letters A, B, *f*, C, *g*, D, E; the first line A being, according to his observations, the extreme boundary of the red rays, and the last line E the extreme boundary of the *violet* rays. The correspondence of these lines with those of Fraunhofer I have with some difficulty ascertained to be as follows:—

A, B, *f*, C, *g*, D, E,—Wollaston.
B, D, *b*, F, G, H,—Fraunhofer.

There is no single line in Fraunhofer's drawing in the spectrum (nor is there any in the real spectrum), coincident with the line C of Wollaston; and indeed he himself describes it as not being "so clearly marked as the rest." I have found, however, that this line C corresponds to a number of lines half-way between *b* and F, which, owing to the absorption of the atmosphere, are particularly visible in the light of the sky near the horizon. In order to have seen the lines B and H of Fraunhofer, especially the last, Dr Wollaston's "beam of daylight" must have come from a part of the sky very near the sun's disc."

Prismatic Spectrum.

Table showing the Indices of Refraction corresponding to the Principal Fixed Lines of the Spectrum, in various Media, according to Fraunhofer.[1]

Prismatic Spectrum.

Refracting Media.	Bm	Cm	Dm	Em	Fm	Gm	Hm
Flint-glass, No. 13	1·627749	1·629681	1·635036	1·642024	1·648260	1·660285	1·671062
Crown-glass, No. 9	1·525832	1·526849	1·529587	1·533005	1·536052	1·541657	1·546566
Water	1·330935	1·331712	1·333577	1·335851	1·337818	1·341293	1·344177
Ditto	1·330977	1·331709	1·333577	1·335849	1·337788	1·341261	1·344162
Solution of potash in water	1·399629	1·400515	1·402805	1·405632	1·408082	1·412579	1·416368
Oil of turpentine	1·470496	1·471530	1·474434	1·478353	1·481736	1·488198	1·493874
Flint-glass, No. 3	1·602042	1·603800	1·608494	1·614532	1·620042	1·630772	1·640373
Ditto No. 30	1·623570	1·625477	1·630585	1·637356	1·643466	1·655406	1·666072
Crown-glass, No. 13	1·524312	1·525299	1·527982	1·531372	1·534337	1·539908	1·544684
Ditto	1·554774	1·555933	1·559075	1·563150	1·566741	1·573535	1·579470
Flint-glass, No. 23, prism of 60°	1·626596	1·628469	1·633667	1·640495	1·646756	1·658848	1·669686
Ditto No. 23, prism of 45°	1·626564	1·628451	1·633666	1·640544	1·646780	1·658849	1·669680

Illuminating power of the spectrum.

Before he proceeded to employ these results to the construction of achromatic telescopes, Fraunhofer endeavoured

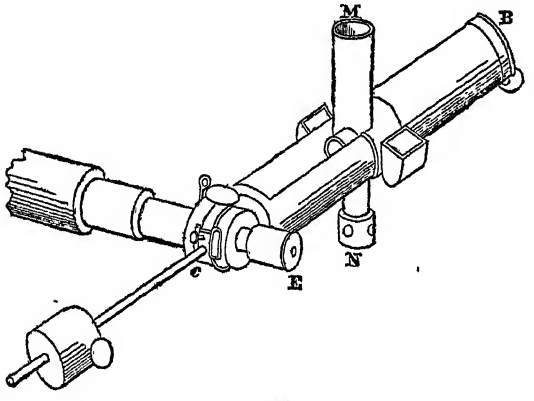


Fig. 88.

to determine by exact measurement the illuminating power of the spectrum at different points. In order to do this, he constructed an apparatus represented in figs. 88, 89. To an eye-glass E, made on purpose for the telescope of the theodolite, he applied a small plane metallic mirror *a*, the edge of which being well defined, cut the field of the telescope in the middle, as shown in the figure. It was placed at an angle of 45° to the axis of the object-glass A, and in its focus. The eye-glass E is pulled out till the edge of the small speculum *a* is distinctly seen. At the side of the eye-glass, and in a direction at right angles to the edge of the speculum *a*, or to the axis of the telescope, he fixed a tube *cb*B, cut at the point *b* in the direction of its length, and in this opening he placed a narrow and a shorter tube MN, whose section is seen at *b*, crossing the larger tube *c*B at right angles. A small flame, supplied with oil from an external vessel, was placed in the tube MN (fig. 88), so as to be in the axis of the tube *c*B. At the point of the

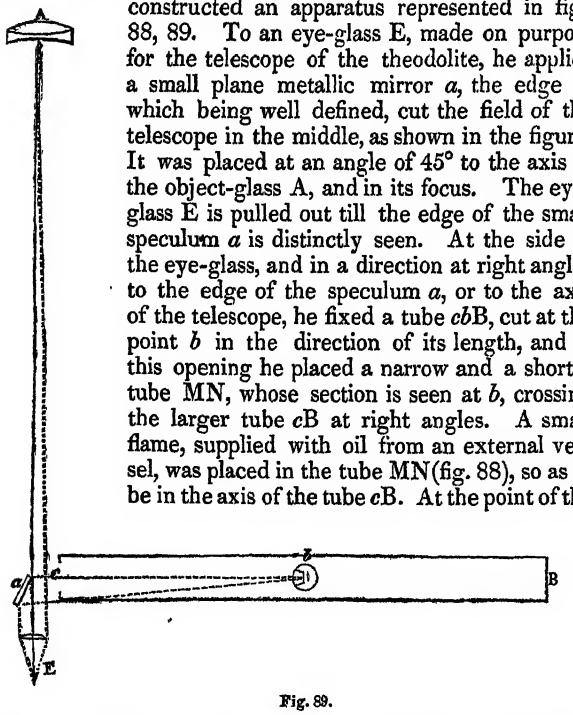


Fig. 89.

narrow tube *b* or MN, where it was cut by the axis of the tube *c*B, was a small round aperture for allowing the light of the flame to fall upon the speculum *a*. Hence it follows that the eye at E will see in half of the field the speculum *a* illuminated by the flame, and in the other half the colours of the spectrum formed by a prism placed, as formerly described, before the object-glass A. By making the tube MN and the flame approach the speculum, we increase its degree of illumination, and can therefore make it equal to the illumination of the part of the spectrum which we wish to determine. In this way he obtained for each coloured space in the spectrum a certain distance of the flame from the speculum, which afforded a measure of the intensity of illumination, the squares of the distances being inversely as the intensities.

With the prism of flint-glass, No. 13, having an angle of 26° 24′ 5″, he obtained the following results. Though the experiments were made in clear weather, and at noon, he sometimes perceived, in the course of the observations, a slight change in the density of the light which the prism received. The differences in the four sets of experiments may have been partly owing to this change, and the flame may also have changed its intensity in the course of the observations. If we call the intensity of the light at the brightest part of the spectrum 1, we shall then have the intensities at the different points as under :—

Table showing the Intensity of Illumination at different points of the Spectrum.

Points of the Spectrum where the illumination was measured.	Intensity of Light.				
	Exp. 1.	Exp. 2.	Exp. 3.	Exp. 4.	Mean.
At the line B	0·0100	0·044	0·053	0·020	0·032
At „ C	0·0480	0·096	0·15	0·084	0·094
At „ D	0·6100	0·590	0·72	0·62	0·640
At 2-7ths of DE from E	1·0000	1·000	1·00	1·00	1·000
At the line E	0·4400	0·38	0·61	0·49	0·480
At „ F	0·0840	0·14	0·25	0·19	0·170
At „ H	0·0100	0·029	0·053	0·032	0·031
At „ G	0·00110	0·0072	0·009	0·005	0·0056

Fraunhofer found the brightest part of the spectrum at the distance of nearly $\frac{1}{3}$ or $\frac{1}{4}$ of DE from D.

The results of the preceding experiments are expressed in the curve which accompanies the spectrum in fig. 87, the preceding values in the last column of the table being the ordinates of the curve, and the angular distances BC, CD in the table on the preceding page, for flint-glass, No. 13, being the abscissæ.

If we suppose that the quantity of the light in the differently coloured spaces is represented by the areas of

[1] The Abbé Dutiron has recently made a series of experiments with various kinds of glass, with a new instrument constructed by Brunner of Paris. (See *Annales de Chimie*, 3d series, tom. xxviii.)

Prismatic Spectrum.

the curves BC, CD, we shall obtain the following results,—the area of the space DE being made equal to unity:—

Quantity of light in, or area of,		Quantity of light in, or area of,	
BC	0·021	EF	0·328
CD	0·300	FG	0·185
DE	1·000	GH	0·035

Hence it follows, that in Fraunhofer's spectrum the *most luminous* ray is nearer the *red* than the *violet* end of the spectrum, in the ratio of 1 to 3·5, and that the *mean* ray is almost in the middle of the *blue* space.

Sir John Herschel has rendered visible the chemical rays beyond the visible violet rays: their colour is that of *lavender-gray;* but they require to be concentrated with a lens in order to be seen.[1] Prismatic Spectrum.

M. Fraunhofer next proceeds to apply these interesting results to the construction of achromatic combinations for telescopes. From his table, given at the top of the preceding page, he obtains the following ratios of the different dispersive powers of the differently coloured rays in the different combinations mentioned in the first column:— Achromatic combinations.

Table showing the Ratios of the Dispersion of the differently-coloured Rays for each combination of Media.[2]

Refracting Media.	Cn′—Bn′ / Cn—Bn	Dn′—Cn′ / Dn—Cn	En′—Dn′ / En—Dn	Fn′—En′ / Fn—En	Gn′—Fn′ / Gn—Fn	Hn′—Gn′ / Hn—Gn
Flint-glass, No. 13, and water	2·562	2·871	3·073	3·193	3·460	3·726
Flint-glass, No. 13, and crown-glass, No. 9	1·900	1·956	2·044	2·047	2·145	2·195
Crown-glass, No. 9, and water	1·349	1·468	1·503	1·560	1·613	1·697
Oil of turpentine and water	1·371	1·557	1·723	1·732	1·860	1·963
Flint-glass, No. 13, and oil of turpentine	1·868	1·844	1·783	1·843	1·861	1·899
Flint-glass, No. 13, and kali	2·181	2·338	2·472	2·545	2·674	2·844
Kali and water	1·175	1·228	1·243	1·254	1·294	1·310
Oil of turpentine and kali	1·167	1·268	1·386	1·381	1·437	1·498
Flint-glass, No. 3, and crown-glass, No. 9	1·729	1·714	1·767	1·808	1·914	1·956
Crown-glass, No. 13, and water	1·309	1·436	1·492	1·518	1·604	1·651
Crown-glass and water	1·537	1·682	1 794	1·839	1·956	2·052
Crown-glass, No. 2, and crown-glass, No. 13	1·174	1·171	1·202	1·211	1·220	1 243
Flint-glass, No. 13, and crown-glass	1·667	1·704	1·715	1·737	1·770	1·816
Flint-glass, No. 3, and crown-glass	1·517	1·494	1·482	1·534	1·579	1·618
Flint-glass, No. 30, and crown-glass, No. 13	1·932	1·904	1·997	2·061	2·143	2·233
Flint-glass, No. 23, and crown-glass, No. 13	1·904	1·940	2·022	2·107	2·168	2·268

Irrationality of the coloured spaces proved.

The important results embodied in the preceding table, completely overturn the opinion of Dr Wollaston respecting the proportionality of the different colours, and establish beyond all question the *irrationality* of the coloured spaces. In the very first combination, for example, of *flint-glass* and *water*, the ratio of the dispersion of the rays in the *red* space BC is as 1 to 2·56, whereas in the *violet* space GH it is as high as 1 to 3·726. In the combination of *flint-glass* and *oil of turpentine*, we have a case where the irrationality is very trifling, and what Fraunhofer has not observed, the irrationality is nothing between the *orange* and *blue* spaces, and almost nothing between the *red* and *indigo*, but very considerable between the *green* and all the other spaces, and a maximum between the green and the violet. The differences of the ratios, too, are *negative* or diminishing in the two first or least refrangible spaces, and *positive* in all the rest, the *negative* differences nearly balancing the *positive* ones; whereas, with very trifling exceptions, the ratios increase towards the most refrangible extremity of the spectrum.

Fixed lines in starlight.

To the Chevalier Fraunhofer we owe also the discovery of many fixed lines in the light of the planets and fixed stars. As the light of our sun is defective in so many rays, it was to be expected that the light of all the planets which he illuminates would be equally defective in the same rays. In the brighter colours of the *moon's* spectrum, we find the same fixed lines as in the sun's light, and in the same place. The spectra from the light of *Mars* and *Venus* contained the lines D, E, *b*, and F, of solar light, and precisely in the same place. In the spectrum of *Sirius* he was unable to perceive fixed lines in the *orange* and *yellow* colours, but in the *green* he saw a very strong streak, and in the *blue* other two very strong ones, having no resemblance to any of the lines in the solar spectrum. *Castor* gives a spectrum resembling that of *Sirius*. The streak in the green was so intense, that, notwithstanding the weakness of the light, he ascertained by measurement that it occupied the same place as the green streak in Sirius. He distinguished also the two streaks in the blue, but he could not ascertain their place. In the spectrum of *Pollux* he found many weak and fixed lines, which resembled those of *Venus*. The line D he saw distinctly, and occupying the same place as in the pure light. In the spectrum of *Capella* he saw the lines D and *b* as in solar light. The spectrum of *Betalgeus* contains numerous fixed lines, which in a favourable atmosphere are sharply defined. There were lines like the solar ones D and *b*. In the spectrum from *Procyon*, some lines were perceived with difficulty, but they were not sufficiently distinct to be measured. In the orange space, however, he saw a line at D.

In all these stars the light is colourless; that is, the defective rays are equally numerous in the differently coloured spaces of their spectra, or are so balanced that the obstruction of light at these places does not affect the *whiteness* of their light. Presuming that in coloured stars the colour was caused by defective rays being more numerous in one part of the spectrum than in another, Sir David Brewster had an opportunity many years ago of confirming the con- Defective lines in coloured stars.

[1] *Phil. Trans.* 1840, p. 19.

[2] M. Dutiron has also given, in the work already referred to, a table of the dispersive powers of the substances whose refractive powers he had measured.

Prismatic Spectrum.

jecture by examining with a very fine prism of *rock-salt* the *orange-coloured* star of the double star *ζ Herculis*, when seen through Sir James South's largest achromatic telescope. One defective band was observed in the *red* space, and two or more in the blue space, and consequently the *orange* colour of the star was owing to a greater defect of *blue* than of *red* rays.

Longitudinal lines in the spectrum.

In examining the spectrum of the sun, Professor Zantedeschi, now of Padua, discovered a set of longitudinal lines in the spectrum perpendicular to the fixed lines of Fraunhofer, and has published beautiful drawings of them in his *Ricerche sulla Luce*.[1] They were observed by Wartman in 1840, and by various authors; but the general opinion has been, that they arise from minute irregularities or particles of dust on the slit or line of light from which the spectrum is formed. More accurate observations, however, have given a different character to the phenomenon; and M. Babinet, who has investigated the subject, regards it as a true and valuable discovery. Professor Zantedeschi and Professor Ragona Scina have found that the lines are produced only when a lens or telescope is used along with the prism; and M. Babinet, who has observed them with a very fine apparatus made by M. Porro, has given an interesting explanation of them. The lines themselves are sometimes broad and sometimes narrow, generally black, but sometimes luminous, depending on the focal length and nature of the lens or lenses.

When a lens has a proper diaphragm, M. Arago found that, setting out from its focus, the axis of a luminous pencil presents a series of dark and bright points, surrounded with narrow rays, bright and obscure, such as are shown in figs. 126, 127, 128, and described in section 3. Now, in Zantedeschi's experiments "every point of the luminous slit, according to its distance from the prism, the screen, or the eye-glasses, gives dark or bright spots, which are transformed by the action of the prism into longitudinal lines either dark or bright. The centre of a black ring, in dilating itself longitudinally, will give a large black line. The centre of a brilliant ring will in like manner produce a large bright line, coloured prismatically from red to violet. The dark and bright narrow rays will be produced from the dark and bright narrow rings which surround the bright and dark centres; and finally, according to all the circumstances of the relative position and magnitude of all the pieces of the apparatus, we ought to have an immense variety in the position and brightness of the different longitudinal lines."[2]

Bright lines in spectra of different flames.

In the spectrum of the *light* of a lamp, and generally of all white flames, none of the defective lines are found, and consequently all such flames contain rays which do not exist in the light of the sun and stars. Fraunhofer, however, observed in the *orange* space of the spectrum from the light of a lamp a bright line more distinct than the rest of the spectrum. He found it to be double, each bright line corresponding with each of the two dark lines forming the line D of the solar spectrum, already described in the preceding section. If we throw any of the salts of soda into the flame, the bright *orange* line D becomes more brilliant, and I have discovered in the *salted-wick* flame a bright line placed nearly half-way between the two that compose D. On the less refrangible side of D I have found three equidistant bright lines in the salted-wick spectrum, the least refrangible of the three corresponding with a defective line in the solar spectrum lying between D and D1 of Fraunhofer. I have discovered also a band in the solar spectrum corresponding with the space between the two of the most refrangible of these three bright lines. Designating the two lines of D by the letters *a*, *b*, and the other three bright lines by *c*, *d*, *h*, and the small line between *a* and *b* by *e*, we have $ab = cd = dh$; $bc = 1\frac{1}{2}ab$, and *ae* less than *eb*.

Prismatic Spectrum.

When *nitrate of strontian* is thrown into an *alcohol* flame, a great number of *brilliant red lines* are exhibited on the *most* refrangible side of D9, corresponding with defective lines in the pure light, and a few on the less refrangible side of D.

In the spectrum produced by the combustion of *nitre* upon charcoal I have observed brilliant red lines corresponding with the double lines A and B, and with the group of eight lines between A and B in Fraunhofer's map.[3]

In a series of experiments on the spectra produced in the combustion of various mineral and saline substances in oxygen and carburetted hydrogen gas, I observed many defective bands and lines, which gave to the flames the colour of the predominating rays, and also numerous bright lines analogous to those which have already been described.[4]

Sect. VI.—On the Physical Properties of the Spectrum.

Physical properties of the spectrum.

The physical properties of the spectrum, which have been the subject of experimental investigation, are its *heating* power, and the *chemical* and apparently *magnetical* influence of its rays.

Heating power.

Heating Power of the Spectrum.—That the heat of the coloured rays should be most intense where their light was strongest was long the general belief of philosophers; and Landriani, Rochon,[5] and Sennebier, found by direct experiment that the highest temperature existed in the *yellow* space. Sir W. Herschel, however, found that the heating power increased from the *violet* to the *red* space, and that the thermometer continued to rise when placed beyond the visible red extremity of the spectrum. He therefore drew the conclusion, that there were invisible rays in the light of the sun which had the power of producing heat, and which had a less degree of refrangibility than red light. Sir W. Herschel attempted in vain to determine the index of refraction of the extreme invisible ray which possesses the power of heating; but he ascertained that at a point $1\frac{1}{2}$ inch distant from the extreme red ray the invisible rays exerted a considerable heating power, even though the thermometer was placed at the distance of 52 inches from the prism.

Sir W. Herschel.

Sir Henry Englefield.

In 1801 Sir Henry Englefield repeated these experiments; but he does not acquaint us with the kind of glass of which his prism was made. He obtained the following results, which confirm those of Sir William Herschel:—

Colours of the Spectrum.	Temperature, Fahr.
Blue	56
Green	58
Yellow	62
Red	72
Beyond red	79

[1] Chap. iii., Venezia, 1846. [2] *Comptes Rendus*, tom. xxxv., p. 415. [3] Ibid., tom. xxx., p. 578.

[4] See a brief notice of these experiments in the *Report of the British Association* for 1842, p. 15, and the *North British Review*, vol. vi., p. 237.

[5] The Abbé Rochon used a prism of flint-glass, and a thermometer containing spirits of wine, and he found the maximum temperature in the *yellow-orange* rays. See his *Opuscules*, 1783. Dr Hutton, in his *Philosophy of Light and Heat*, Edin. 1794, p. 38, remarks that "the compound light, which is *white*, has a greater power of giving vision in proportion to its power of exciting heat; whereas in the *red* species it is the opposite, for here the power of exciting heat is great in proportion to its power of giving vision."

Prismatic Spectrum.

From our author's own account of the method of making these experiments, we place no confidence in the principal result respecting the invisible rays. "*As I had nothing to do with light,*" says he, "it was not necessary to darken the room; and as I wished to accumulate as large a portion of solar heat as possible, *I placed the prism in an open window.*" As the whole interest of these experiments was concentrated in the determination of *invisible* heating rays, Sir Henry had a great deal to do with light, as the whole question turned upon an exact appreciation of the *termination of the spectrum.* In a dark room the spectrum is much longer than in open day; and we have reason to believe from experiment, that Sir Henry Englefield's spectrum did not visibly extend beyond the line C of Fraunhofer; so that his maximum temperature of 79° was actually found in the red rays.

Later experiments.

With the view of throwing light upon this subject, Sir David Brewster has endeavoured to ascertain the visible extent of the spectrum by various methods of condensing the light, and absorbing by coloured media the luminous parts of the spectrum. By these means he has traced the visible spectrum, and the fixed lines in it, as far beyond the line A as the distance of the group of lines *a* is from A, and has seen it indistinctly to a distance as great as AB beyond A. Hence there cannot be the least doubt that the experiments beyond the visible red were actually made when the thermometer was placed in the red space. He does not, however, infer from this that there are no invisible rays beyond the red; but merely that the experiments of Herschel and Englefield were made in a part of the spectrum where rays of light actually exist. On the contrary, Sir D. Brewster concludes that there are rays of heat of all degrees of refrangibility, and consequently consisting of waves of all degrees of breadth and velocity. When produced by a slight vibratory movement, the waves of heat are broad and slow; as the temperature rises, they become narrower and quicker in their motion. When their velocity is such as to equal that of the extreme red ray, they become faintly visible, and the other colours are successively produced by quicker motion, till white light is radiated. This seems to be the process by which incombustible bodies are gradually raised from the deepest red to the brightest white; and if we examine by means of a prism the changes which take place in the gradually increasing light, we shall find that the different rays of the spectrum are successively added to the red light.[1] He conceives, therefore, that the sun emits rays of all degrees of refrangibility, extending probably far beyond the visible extremity of the violet, and though not capable of being rendered sensible, yet exercising powerful influences in the economy of nature.

Berard.

M. Berard and Sir Humphry Davy obtained results analogous to those of Sir W. Herschel,—M. Berard finding the maximum heat at the very extremity of the red ray, and Sir H. Davy beyond it.

Wunsch.

The most valuable series of experiments on this subject were made by Professor Wunsch and Dr Seebeck of Berlin. So early as 1807, Professor Wunsch[2] had made experiments with *prisms* of various substances, and obtained the following results:—

Substances of which the Prisms were made.	Place of Maximum Heat.
Alcohol	Yellow space.
Oil of turpentine	Yellow space.
Water	Yellow space.
Green glass	Red
Yellow glass	Extreme red.

Seebeck.

These results were confirmed by Dr Seebeck, who obtained the following new results:—

Substances of which the Prisms were made.	Place of Maximum Heat.
Sulphuric acid, concentrated	Orange.
Solution of sal-ammoniac	Orange.
Solution of corrosive sublimate	Orange.
Crown-glass	Middle of red.
Plate-glass	Middle of the red.
Flint-glass, English	Beyond the red.
Ditto Bohemian	Beyond but nearer the red.

Prismatic Spectrum.

Brewster.

The explanation which was given of these results by Sir David Brewster accounts in a very satisfactory manner for all the phenomena. He conceives that transparent bodies have the power of absorbing or stopping certain rays of the thermometric spectrum, as Dr Robison called it, in the same manner as *coloured* bodies have the power of stopping certain rays of the luminous spectrum. These last bodies necessarily became coloured by stopping certain rays; but as the eye is not sensible to heat in the same manner as to light, the absorptive power of transparent bodies for heat can only be proved by the thermometer. He considers *water* as the type of bodies which are uniformly transparent for heat, as its maximum of heat coincides with its maximum of light. A prism of crown-glass, on the contrary, is less uniformly transparent for heat; and its maximum of heat is in the red space, because it has absorbed much of the heat in the yellow space. In like manner, flint-glass has absorbed more of the heating rays in the red than the crown-glass, and hence its maximum is about the extremity of the red, or beyond the end of the spectrum as commonly seen. In coloured media the maximum ordinate of their luminous spectrum shifts along the whole prismatic spectrum; sometimes there are *two* or *more maxima* of light, and sometimes narrow and wide spaces entirely defective in light. Hence Sir David Brewster[3] supposes that there are defective spaces and lines in the thermometric spectrum.

This view of the subject suggests a new mode of investigating the phenomena of the heating rays. If we take a prism of coloured glass to investigate the dark spaces and lines produced by absorbing media, we shall only have a very imperfect approximation to the true results; that is, we never could have absolutely dark spaces in the spectrum as long as all the rays that went to the formation of the spectrum passed through *all the different thicknesses of the prism.* The thinnest parts of the prism allow all the rays to pass, and consequently illuminate the whole spectrum, so that the actions of various thicknesses of the media are confounded, and the real absorptive action at a given thickness concealed. In like manner, in the spectrum of heat, the heating rays which pass through the thin parts of the prism will throw heat into every part of the spectrum; and hence the experiments should be made with the frustums of prisms, where the difference of thickness is small, and the want of area made up by an increased height of the prism. The best way, however, of making the experiments would be to use a compound prism constructed as in fig. 90, where AB, MN, is the section of a compound prism consisting of four frusta of prisms, AB, *ab*, *a'b'*, &c., the frustum AB being part of a prism ABC, the frustum *ab* part of a prism *abc*, &c.; or this compound prism, in place of being ground out of the mass, which would be difficult, though practicable, might be composed of a single prism ABC, with parallel plates

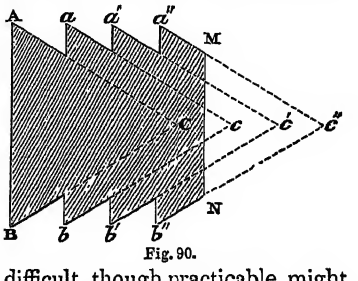


Fig. 90.

[1] See Professor Powell's "Report on Radiant Heat," *British Association Reports*, vol. i., p. 295.
[2] *Magazin der Gesellsch.*, &c.
[3] Professor Powell's *Report*, pp. 293, 294.

Prismatic Spectrum.

of the same glass, added by cement so as to compose the notched parallelogram ABMN. Very interesting results might also be obtained by using spectra formed by interferences in the manner we shall afterwards describe.

In all experiments with fluid prisms the results are perplexed with the effects of the plates of glass by which the prisms are confined, in the same manner as we would disturb and indeed nullify the results respecting the absorption of light by coloured fluids, were we to confine them in hollow prisms made of coloured glass. The only method of remedying this defect in the experiment would be to form the spectrum by a prismatic vessel of the fluid, whose upper surface AC is formed by gravity, and its lower surface BC by a plate of highly polished silver, which reflects back the spectra through the first surface.

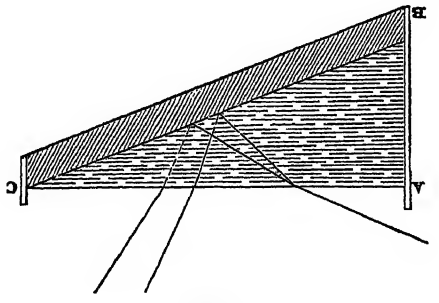


Fig. 91.

According to Berard's experiments the calorific rays of the spectrum are capable of being doubly refracted and polarized like those of light, and he obtained the same result with culinary heat,—the heat of a dark body below redness being substituted for solar heat.[1]

Herschel.

The *calorific* or *thermic* spectrum has been recently examined by Sir John Herschel, by means of a new and ingenious process,—namely, by the *drying* power of the heat itself.

A piece of thin paper, such as is used for foreign correspondence, is blackened on one side by Indian ink, or, what is better, by a smoky flame, and the other, or white side, is saturated with good rectified spirit of wine, which will make it uniformly black. The solar spectrum being thrown upon this wet side of the paper, its heating power will be displayed by the whiteness produced by the evaporation of the alcohol. By this process, and with an object-glass of crown and flint glass, and a prism of flint-glass, he obtained the following results:—The thermic spectrum is continuous throughout the length of the luminous spectrum, but at a point α, considerably beyond the extreme red, the heating power is a *maximum*, having gradually increased up to this point. It then diminishes slightly for a short space, and again reaches a second maximum at β; from this point it diminishes and ceases altogether. It then reappears, and reaches another maximum at γ; diminishes again; ceases, and reaches a fourth maximum at δ. Traces of a fifth maximum were seen at ϵ.

Calling the length of the luminous spectrum 57,—viz., 43 on the violet side of the yellow line D, and 14 on the red side,—the distances of the *maxima* will be as follows:—

$\alpha = 18{\cdot}2$ from the line D.
$\beta = 26{\cdot}7$
$\gamma = 35{\cdot}7$
$\delta = 45{\cdot}1$
$\epsilon = 55$

The thermic spectrum thus extending the whole length of the luminous spectrum beyond the line D.

With a crown-glass prism and lens, "the insulation, of γ," says Sir John Herschel, "was much less sensible, and the separation of α and β hardly to be perceived. This would go to point out the flint-glass as the origin of the spots; and to that idea I rather incline. With a prism of pure water, and also with one of a saturated solution of muriate of lime, the spot γ was greatly enfeebled, and δ invisible. Green glasses cut off nearly the whole thermic spectrum."[2] Prismatic Spectrum.

On the Chemical Effects of the Spectrum.—It was long ago observed by Scheele that muriate of silver was rendered much blacker in the violet rays of the spectrum than in any other part of it.[3] In the year 1801 Professor Ritter of Jena exposed muriate of silver in various parts of the spectrum, and also beyond its apparent limits. He found that the action was least of all in the red rays, greater in the yellow, greater still in the blue and violet, and greatest of all beyond the *visible* violet rays. Dr Wollaston and M. Beckman obtained a similar result, apparently without knowing what had been done by Ritter. In repeating the experiments of Scheele with white muriate of silver, "he found that the blackness extended not only through the space occupied by the violet, but to an equal degree, and to about an equal distance, beyond the visible spectrum; and that by narrowing the pencil of light *the discoloration may be made to fall* ALMOST ENTIRELY beyond the violet. It would appear, that this and other effects usually attributed to light, are not in fact owing to any of the rays usually perceived, but to *invisible* rays that accompany them; and that if we include two kinds that are invisible, we may distinguish upon the whole *six* species of rays into which a sunbeam is divided by refraction."[4] Chemical effects of the spectrum. Muriate of silver.

The phrase *almost entirely* beyond the violet, used by Dr Wollaston, cannot be considered as indicating the existence of invisible rays, even if we did not know from the experiments of Fraunhofer and others, that the visible violet space extends greatly beyond the place where both Ritter and Wollaston found the muriate of silver to be blackened. The existence of invisible rays, therefore, however probable, cannot be regarded as a scientific fact.

The chemical action of the least refrangible rays upon gum guiacum was discovered by Dr Wollaston. Having washed a card with a solution of this gum in alcohol, he found that it acquired a *green* colour from the concentrated violet and blue rays. No change of colour was effected by heat; but in the red rays the tinged card lost its *green* and recovered its original colour. When the tinged card was placed in carbonic acid gas, the violet rays could not make it green; but when made green as before, it was speedily restored to its original yellow colour by the red rays. As Dr Wollaston found that the back of a heated silver spoon restored the green colour as well as the red rays, we cannot attach any definite meaning to these experiments. Gum guiacum.

MM. Gay-Lussac and Thenard discovered a very energetic chemical action of the solar rays. On exposing to a pencil of solar light a mixture of hydrogen gas and chlorine, in equal volumes, a detonation of the mixed gases took place, and hydrochloric acid (muriatic acid) was formed. Hydrogen and chlorine.

M. Berard repeated the experiments with muriate of silver, and with the preceding mixture of gases, which he placed in the different coloured spaces of the spectrum, and he found that the chemical action was in every case more powerful towards the violet extremity and a little beyond it. M. Berard likewise concentrated the least refrangible half of the spectrum by means of a lens, and then the most refrangible half. The latter, though the most intense, pro- M. Berard.

[1] *Mém. de la Societé d'Arcueil*, 1817, tom. iii. A full account of these experiments, occupying a whole chapter of eighteen pages, will be found in Biot's *Traité de Physique*, tom iv., p. 600.

[2] Brewster's *Optics*, p. 101.

[3] *Traité de l'Air et du Feu*, sect. 66.

[4] *Phil. Trans.* 1802.

Prismatic Spectrum.

duced no effect upon the muriate of silver, but the former blackened it in less than ten minutes.[1]

Mrs Somerville.

Mrs Somerville[2] found that the chemical rays passed as freely through blue glass coloured with cobalt, as through colourless glass. Having dipped a piece of paper in a solution of muriate of silver, and cut it into two parts, one of them was placed under a blue glass, and the other under a white glass, at the same instant. The one did not become black more than the other, and there was no difference in the intensity of their colour.

Dr Young.

Dr Thomas Young made a very interesting experiment with the view of determining if the invisible chemical rays interfered with the luminous ones. He produced the Newtonian rings with a thin plate of air, and having formed an image of them by means of the solar microscope, he threw this image upon paper dipped in a solution of nitrate of silver, and placed it at the distance of about 9 inches from the microscope. "In the course of an hour," says he, "portions of three dark rings were very distinctly visible, much smaller than the brightest rings of the coloured image, and coinciding very nearly in their dimensions with the rings of violet light that appeared upon the interposition of violet glass. I thought the dark rings were a little smaller than the violet rings, but the difference was not sufficiently great to be accurately ascertained. It might be as much as one-thirtieth or one-fortieth of the diameter, but not greater."[3]

M. Arago.

A more decisive experiment was afterwards performed by M. Arago, who formed a set of fringes by the interference of two solar pencils proceeding from a common origin, and having kept them very steadily for a long time upon the same part of a piece of paper rubbed with muriate of silver, a series of black lines were traced upon the paper, leaving their intervals smaller than those of the dark and bright fringes formed by violet light.

Sir John Herschel.

In the summer of 1831 we had the satisfaction of being shown by Sir John Herschel a very interesting experiment on the chemical action of the violet rays. When a solution of platinum in nitro-muriatic acid[4] is mixed with lime-water, no precipitation to any considerable extent takes place in the dark, a slight flocky sediment only being formed after long standing. But if a fresh mixture, or an old one cleared by subsidence of this sediment, is exposed to the sun's rays, it instantly becomes milky, and a *white* precipitate is copiously formed. If the solution of platina is in excess, the precipitate is of a pale yellow colour. In the common light of a cloudy day, the same effect is produced more slowly. When tubes containing the mixture are exposed within red fluids, or even yellow ones which absorb the violet rays, no precipitation takes place.[5]

As the art of PHOTOGRAPHY, comprehending the *daguerreotype* and *talbotype*, depends on a knowledge of the chemical properties of the spectrum, we must refer our readers to that article for what is practical in the art. It is only to the chemical properties of the spectrum that we can here direct the attention of the reader, confining ourselves to the researches of Sir John Herschel and M. Edmund Becquerel.

In order to give a distinct account of the results obtained by Sir John Herschel, we must refer to the luminous spectrum which he actually used in his experiments. Its total length was 53·92 thirtieths of an inch, the distance of the violet end from the line D being + 40·62, and of the red extremity from the same line − 13·30.

1. *Nitrate of Silver.*—Paper washed with a solution, specific gravity, 1·132. The colour of the spectrum impressed upon this paper by the chemical rays was *pale brown*, inclining to *pink*, and the most intense part was about the middle of the blue ray. The total length was 85 parts, and it terminated at the line D. The point of maximum intensity was 23 parts on the violet side of D. Prismatic Spectrum.

Nitrate of Silver, with Muriate of Soda.—The paper was first washed with the nitrate, specific gravity, 1·132; then with the muriate of salt + 19 water; and again with the nitrate, specific gravity, 1·096. The spectrum impressed upon this paper is more variously coloured than any other. The tint is a pretty high *red* at − 7·6, beginning to pass into *green* at − 3·8, through a kind of livid mixed tint. The best *green*, however, which is of a sombre and dull character, is developed a little above (+) D, and covers a breadth of about 4 parts. From that point, with a barely perceptible tinge of dark *blue*, it becomes rapidly an intense *black*, which at + 80 dies away into a *purplish-brown*, and terminates the spectrum at + 90·23; the whole length of the chemical spectrum, or the discoloured impression, being + 97·83 parts.

Nitrate of Silver, as before, with *hydro-bromate of potash*, instead of muriate of soda. The spectrum impressed upon paper thus prepared is a most extraordinary one. The *instant the rays fall upon it*, the action begins over its whole length, and the intensity is the same everywhere, but just at the extremities, where it gradually dies away. It extends, too, all the way to the extremity of the visible *red* rays. Its tint is a *grayish-black*. At the red extremity a contrary or oxidizing action now commences, producing *whiteness* in the paper, and extends to − 22·67. Hence the extent of the chemical beyond the luminous spectrum is − 9·37. The most refrangible extremity of the darkened portion is + 90·50, the total length of the darkened portion is 105·55, and the whole length of the paper visibly affected 116·77.

Edmund Becquerel.

The chemical and phosphorogenic properties of the spectrum have been more recently studied by M. Edmund Becquerel. He has given measures and drawings of the chemical spectrum, which acts upon *iodide of silver*, *chloride of gold*, *chromic acid*, and *guiacum*. He has also given the chemical spectra obtained upon iodide of silver by means of the rays which have passed through colourless screens, such as *sulphate of quinine*, *creasote*, &c., and through coloured screens, such as *yellow* and *blue glass*, and solutions of *tournesol* and *sulpho-cyanuret of iron*. He found that the chemical rays which extend from the line H to their extreme limit render artificial phosphori luminous; while the rays from H to A extinguish the phosphorescence thus produced. In Canton's phosphorus (*sulphuret of calcium*) there is a dark space in the phosphorogenic spectrum nearly bisecting it. With the Bologna phosphorus (*sulphuret of barium*) there is no dark space, and the spectrum is shorter. With transparent screens of *turpentine* and *naphtha* the more refrangible half of the phosphorogenic spectrum is almost extinguished, while with *creasote* and *sulphate of quinine* that hue is completely extinguished.[6] Phosphoric light, however produced, I have found to contain rays of all colours and refrangibilities.[7]

Magnetic influence of the solar rays.

Magnetic Influence of the Solar Rays.—Though many interesting and apparently accurate experiments have concurred to indicate the existence of this property of light, yet subsequent inquiries have thrown considerable doubt upon the conclusions which have been drawn from them. Dr Morichini, a Roman physician, first succeeded in 1813 in magnetizing small needles, by making the focus of violet rays collected by a lens pass repeatedly from the middle to one end of a needle, without touching the other half.

[1] Biot's *Traité de Physique*, tom. iv., pp. 673, 674.
[2] *Philosophical Transactions*, 1826, part ii., p. 136.
[3] *Elements of Natural Philosophy*, vol. ii., p. 647.
[4] The excess of acid must be neutralized by the addition of lime, and the solution well cleared by filtration.
[5] See *Lond. and Edin. Phil. Mag.*, No. 1, July 1832, p. 58.
[6] See *Annales de Chim. et de Phys.* 1843, tom. ix., pp. 257–323.
[7] Brewster's *Optics*, p. 103.

Prismatic Spectrum.

By continuing this process for an hour, the needle had acquired distinct polarity.

Mrs Somerville.

In 1825 Mrs Somerville repeated, in a different way, the experiments of Morichini. She took a slender sewing-needle an inch long, quite devoid of magnetism, and having covered half of it with paper, she fixed it to the panel of the wall with wax, so that its uncovered half should receive the violet rays of a spectrum formed by an equiangular prism of flint-glass, whose refracting faces were each 1·4 by 1·1 inches, and which was placed about five feet from the wall. The needle was placed in a vertical plane nearly perpendicular to the magnetic meridian, and inclined to the horizon, and as the sun advanced to the meridian, the needle was moved parallel to itself, to keep it in the sun's rays. In less than two hours, when the sun had just passed the meridian, the exposed half of the needle attracted the south and repelled the north pole of the magnetic needle. In the blue and green rays the needles were magnetized, but less frequently, and always after a longer exposure, but the magnetism was always as strong as in the violet. The indigo rays were nearly as efficacious as the violet.

Baumgartner.

M. Baumgartner of Vienna,[1] while repeating the experiments of Mrs Somerville, found that a steel wire, some parts of which were polished, while the rest were rough or without lustre, were magnetized by the action of the white light of the sun, each polished part exhibiting a *north*, and each unpolished part a *south* pole.

Barlocci.

A less equivocal method of proving the magnetic influence of white light presented itself to Professor Barlocci. An armed natural loadstone, capable of carrying a weight of 1½ Roman pounds (a Roman pound is equal to 339·179 grammes), after *three hours'* exposure to strong sunlight, was able to carry 2 oz. or one-sixth of a pound more, and after an exposure of 24 hours, its force was almost *doubled*. A second loadstone of nearly the same power was put into a dark place of the same temperature as that of the solar rays, but acquired no additional strength.

Zantedeschi.

Among the most active labourers in this department of science we must rank M. Zantedeschi of Padua.[2] He had early obtained results similar to those of Morichini, and he had remarked that suspended wire needles, devoid of all magnetism, and having one of their ends exposed to the white light of the sun under a glass receiver, turned that extremity to the north in the plane of the magnetic meridian. In repeating the experiment of Barlocci with artificial magnets, M. Zantedeschi found that a horse-shoe magnet, carrying 13⅓ ounces, carried 3⅓ oz. more after three days' exposure to the sun, and by continued exposure, was able to carry 31 oz.

Riess and Moser.

A great degree of doubt has been cast upon the conclusiveness of all these researches by a series of well-managed experiments more recently made by MM. Riess and Moser, who found that no effect was produced upon magnetic needles by the action of the sun's rays.[3]

Sect. VII.—Recent Discoveries respecting the Spectrum.

New analysis of the spectrum.

The analysis of white or compound light by the prism was made and perfected by Sir Isaac Newton; but though the prism could not decompose them, he committed a mistake in concluding that the colours of the spectrum were simple and homogeneous; "that to the same degree of refrangibility ever belonged the same colour, and to the same colour ever belonged the same degree of refrangibility." Now, though it is quite true that the *green* and *orange* colours of the spectrum cannot be decomposed *by the prism* into more simple ones, the one into *blue* and *yellow*, and the other into *yellow* and *red*, yet they can be decomposed by other means. This opinion respecting the compound nature of the colours of the spectrum, and the inability of the prism to analyze them, was first maintained by Sir David Brewster,[4] who, with the view of placing it beyond a doubt, undertook a series of experiments, in which he examined the effects produced on the solar spectrum by viewing it through a great number of coloured media, and reflecting it from coloured surfaces. By these experiments he not only established the accuracy of his first opinion, that the *green* and *orange* colours of the spectrum were compound, the one consisting of *blue* and *yellow*, and the other of *red* and *yellow*, but was led to the more general result, that the whole spectrum was compound, consisting of three equal and superposed spectra of *red*, *yellow*, and *blue* light.[5] The following are the general results which he obtained:—

Prismatic Spectrum.

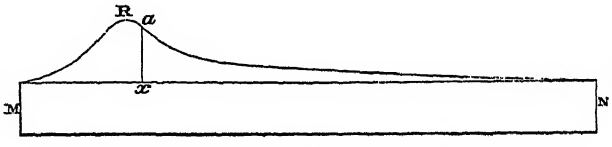
"1. White light consists of *three* simple colours, *red*, *yellow*, and *blue*, by the mixture of which all other colours are formed.

"2. The solar spectrum, whether formed by prisms of transparent bodies, or by gratings or grooves in metallic and transparent surfaces, consists of *three* spectra of *equal length*, *beginning and terminating at the same points*, viz., a *red* spectrum, a *yellow* spectrum, and a *blue* spectrum.

"3. All the colours in the solar spectrum are *compound* colours, each of them consisting of *red*, *yellow*, and *blue* light in different proportions.

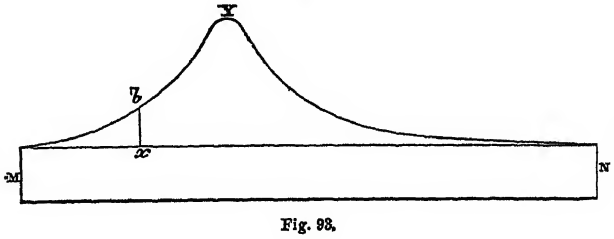
"4. A certain quantity of *white light*, incapable of being decomposed by the prism, in consequence of all its component rays having the same refrangibility, exists at every point of the spectrum, and may at some points be exhibited in an insulated state.

"This remarkable structure of the spectrum will be better understood from figs. 92, 93, 94, representing the three separate spectra, which are shown in their combined state in fig. 95.



Red.

Fig. 92.



Yellow.

Fig. 93.

Blue.

Fig. 94.

"In all these figures, the point M corresponds with the *red*, or *least refrangible* extremity of the spectrum, and N with the *violet* or *most refrangible* extremity; and the ordi-

[1] *Zeitscrift*, tom. i., p. 263.
[2] *Edinburgh Journal of Science*, No. 5, N.S., 1830, p. 76.
[3] *Edinburgh Journal of Science*, No. 4, p. 225.
[4] *Edin. Trans.*, vol. ix., p. 48.
[5] *Edin. Trans.*, vol. x., p. 123.

Prismatic Spectrum.

nates *ax*, *bx*, *cx*, of the different curves, MRN, MYN, MBN, represent the intensity of the *red*, *yellow*, and *blue* ray at any point *x* of the spectrum.

"If the distance M*x* in all these spectra be equal, then, in the combination of them shown in fig. 95, the ordinates

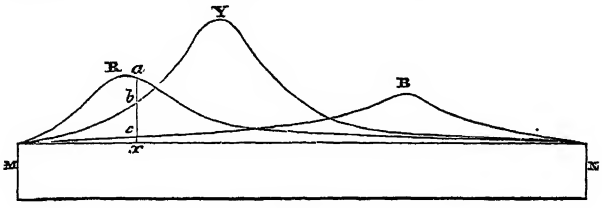


Fig. 95.

ax, *bx*, *cx* will indicate the nature and intensity of the colour at any point *x* of the red spectrum. Thus, let

"The ordinate for *red* light $ax = 30$,
yellow $bx = 16$,
blue $cx = 2$,
$ax + bx + cx = 48$ rays,

then the point *x* will be illuminated with 48 rays of light,—viz., 30 of red, 16 of yellow, and 2 of blue light.

"Now, as there must be certain quantities of red and yellow light which will form white, when combined with two blue rays, let us assume these, and suppose that white light, whose intensity is 10, will be formed by 3 red, 5 yellow, and 2 blue rays; hence it follows that the point *x* is illuminated by

"Red rays.....27
Yellow rays 11
White light 10
48 rays.

Or, what is the same thing, the light at *x* will be *orange*, rendered brighter by a mixture of white light. The *two* blue rays, therefore, which enter into the composition of the light at *x*, will not communicate any blue tinge to the prevailing colour.

"If the point *x* is taken nearer M, and if at that point the *blue* rays are more numerous in proportion to the *yellow* than 2 to 5,—that is, if they are as 3 to 5,—then there will be one blue ray more than what is necessary to make white light with the two yellow and the three red rays, and this blue ray will give a blue tinge to that part of the spectrum, or will modify the peculiar colour of *pure red* light. In like manner, the *blue* extremity of the spectrum may have its peculiar colour modified by an excess of *red* rays, so as to convert it into *violet* light."

Sir Isaac Newton and Fraunhofer, and many persons besides, have, from long observation of the solar spectrum, concluded that there is a *homogeneous unmixed yellow*, and a *homogeneous unmixed orange* space in the spectrum. Newton makes the *yellow* space 40, and the *orange* 27, or 67 in all; while Fraunhofer makes the *yellow* space 27, and the *orange* space 27, or 54 parts of a spectrum whose length is 360 parts. Now, Dr Wollaston declares that a beam of daylight is refracted by the prism into *five colours* ONLY—*red*, *yellowish-green*, *blue*, and *violet*,—and he defines their limits with his usual accuracy. Dr Young, who repeated the same experiments with that exactness which was peculiar to him, declares that the spectrum formed in Dr Wollaston's manner, consists of *four colours* ONLY,—*red*, *green*, *blue*, and *violet*,—"the colours differing scarcely at all in quality within their respective limits." Now both these accurate observers have rejected the *yellow* and *orange* spaces almost entirely, with the exception of the narrow line of yellow light formerly mentioned, thus running counter to all the observations of Newton and Fraunhofer. The cause of such a difference is this:—The light analyzed by Wollaston was the *blue light of the sky*, which had been deprived, by absorption, of many of its rays having the same refrangibility as those which fell upon the prism. Dr Young's *green* space was Sir Isaac Newton's *yellow* space, deprived of most of its *yellow* rays, and the *red* space adjoining the green was Newton's *orange* space, deprived by the absorption of the atmosphere of almost all its yellow rays; and the sharp yellow line noticed by Dr Young, and regarded by Dr Wollaston as a mixture of red and green light, as if these spaces had overlapped a little, is part of the *orange* space of Fraunhofer and Newton, deprived of its *red* rays. This *yellow* band can be produced artificially upon all kinds of white light, and by the absorption of various media. Hence it is obvious, that by comparing the light reflected and modified by the *blue sky* with the direct *light of the sun*, we may obtain irrefragable proof of the compound nature of the yellow and orange spaces. That *red* light exists at the most refrangible extremity, is obvious from its *violet* colour; and that *blue* light exists at the *red* extremity, may be proved by the following observation of Sir W. Herschel.[1] He had occasion to view the prismatic spectrum when reflected from clear turned brass, and he observes, "The colour of the brass *makes the red rays appear like orange*, and *the orange colour is likewise different from what it ought to be.*" Here, then, yellow light was seen at the very red end of this spectrum, and it was seen in consequence of *blue* light having been absorbed by the brass, because *blue* light, mixed with the *orange* observed by Sir W. Herschel, would alone recompose the original red. Here, then, there is a proof that *blue* light, and *yellow* light, and *red* light, all exist in the same place, at the least refrangible end of the spectrum. Effects similar to these may be produced by various coloured media, such as chemical solutions, or the coloured juices of plants; and by such means Sir David Brewster has succeeded *in insulating white light in the spectrum, incapable of being decomposed by the prism.*

Prismatic Spectrum.

The existence of fixed lines in the spectrum, as discovered by Fraunhofer, was a fact unexampled in science. Various coloured bodies were known to absorb particular parts of the spectrum, and their peculiar colour was the necessary consequence of this absorption. Some of them, such as smalt-blue glass, produced at a certain thickness several dark bands in the spectrum, but these bands shaded off by imperceptible degrees, and had no definite boundary.[2] In examining the action of all the coloured solid and fluid bodies which he could command, Sir David Brewster was led to observe the action of nitrous acid gas on the spectrum.[3] With a fine prism of rock-salt, having the largest possible refracting angle, he formed a spectrum with the light of a lamp transmitted through a small thickness of the gas, whose colour was a very pale straw-yellow, and he was surprised to observe the spectrum crossed with hundreds of lines or bands, much more distinctly pronounced than those of the solar spectrum. In the violet and blue spaces the lines were sharpest and darkest; they were fainter in the green, and almost imperceptible in the yellow and red spaces. By an increase in the thickness of the gas,

Action of nitrous acid gas on the spectrum.

[1] *Phil. Trans.* 1800, vol. xc., p. 255.

[2] A remarkable example of a definite action on a part of the spectrum was discovered by Sir D. Brewster in the triple oxalate of chromium and potash. It absorbs a very definite band on the least refrangible side of B, a part of the spectrum over which it exercises no general absorptive action. This band lies in the space B*α* of Fraunhofer's map, so that if *x* is its place, B*x* will be ⅓ B*α*, or its index of refraction in the water spectrum is almost exactly 1·33070. (See *Phil. Trans.* 1835, p. 93.)

Phil. Trans. 1837, part ii., p. 245; *Edin. Trans.*, vol. xii.

Periodical Colours.

the lines were better developed in the yellow and red spaces, and became broader in the blue and violet, a general absorption or extinction of the light advancing from the violet extremity, while a specific absorption was going on on each side of the lines or bands.

"The power of heat alone," says our author, "to render a gas which is almost colourless as red as blood, without decomposing it, is in itself a most singular result, and my surprise was greatly increased when I afterwards succeeded in rendering the same pale nitric acid gas so absolutely black by heat, that not a ray of the brightest summer's sun was capable of penetrating it. In making this experiment the tubes frequently exploded, but by using a mask of mica and thick gloves, and placing the tubes in cylinders of tinned iron, with narrow slits to admit the light, there is little danger of any serious accident."

As the points of maximum absorption in coloured bodies were distinctly coincident with some of the principal lines in the solar spectrum, our author suspected that the same might be true with regard to the nitrous gas lines, and he therefore formed the solar and the gaseous spectrum with light passing through the same aperture, so that the lines in the one stood opposite to those in the other, and their coincidence became a matter of simple observation. He then superimposed the two spectra, when both were formed by solar light, and thus exhibited at once the two series of lines and bands, with all their coincidences and deviations.

Action of the atmosphere on the spectrum.

In his examination of the spectrum, our author was led to the discovery of a system of lines and bands, particularly in the red and green spaces, which at other times wholly disappeared; but by a diligent comparison of these observations, he found that these *lines and bands depended on the proximity of the sun to the horizon, and were produced by the absorptive action of the earth's atmosphere.* "The atmosphere," he remarks, "acts very powerfully round the line D, and in the space immediately on the least refrangible side of it. It develops a beautiful line in the middle of the double line D, and by enlarging a group of small lines on the red side of D, it creates a band almost as dark as the triple line D itself. It widens generally all the lines, but especially the darkest one, which I call *m*, between C and D. It develops a band on the least refrangible side of *m*, and it acts especially upon several lines, and develops a separate band on the most refrangible side of C. The lines A, B, and C are greatly widened, and lines and bands are particularly developed between A and B, and generally throughout all the red space.

"The absorptive action of the atmosphere shows itself in a less precise manner in the production of dark bands whose limits are not distinctly defined. A very remarkable narrow one, corresponding to one produced by the nitrous acid gas, is situated on the most refrangible side of C. Another very broad one lies on the most refrangible side of D, close to a sharp and broad band of yellow light, displayed by the general absorption of the corresponding part of the superimposed blue spectrum. There is also an imperfectly defined atmospheric action, corresponding to a group of lines where Dr Wollaston placed his line C."

Part V.—ON PERIODICAL COLOURS.

Periodical colours.

The phenomena of periodical or recurrent colours, as Dr Young has very appropriately called them, are among the most interesting in optics, and have been treated of by him with great ability under the head Chromatics, though not in a sufficiently popular and descriptive manner. We shall therefore endeavour to give as perspicuous an account as we can of this interesting portion of physical optics.

Sect. I.—On the Interference of Light.

Periodical Colours.

Interference of light.

The discovery of the interference of light in its simplest form is due to Grimaldi, as we have already seen. He admitted the sun's light into a dark room, through two small and equal apertures of a circular form. Two cones of diverging light were thus formed, and by receiving them on a screen held beyond the place where the cones intersected each other, two overlapping luminous circles were seen on the screen. A partially illuminated penumbra surrounded each of these cones, and at the place where the rays from each aperture met, the screen was, generally speaking, more strongly illuminated by the union of the two lights; but the boundaries of the penumbral portions which overlap are much darker than the corresponding portions of the penumbra which do not overlap, as if the one light had at this part put out the other. Upon intercepting the light from one of the apertures, this dark part became brighter, and upon restoring the light it again became darker. The result, therefore, was here unambiguous, and justified the observation of Grimaldi, "that an illuminated surface may be rendered darker by the addition of light."

Dr Hooke made a similar experiment, and observed the darkness produced at the overlapping part of the two cones; but this result, remarkable as it was, seems to have excited no interest during nearly a century and a half, till Dr Young, who was unacquainted with the experiment of Grimaldi, obtained the same result in a different manner, and thus laid the foundation of the most interesting department of physical optics. The following is the experiment which he gave as "*An Experimental Demonstration of the Interference of Light.*"[1] "I made a small hole in a window-shutter, and covered it with a piece of thick paper, which I perforated with a fine needle. For greater convenience of observation, I placed a small looking-glass without the window-shutter, in such a position as to reflect the sun's light in a direction nearly horizontal upon the opposite wall, and to cause the cone of diverging light to pass over a table on which were several little screens of card-paper. I brought into a sunbeam a slip of card about $\frac{1}{30}$th of an inch in breadth, and observed its shadow either on the wall or on other cards held at different distances. Beside the fringe of colour on each side of the shadow, the shadow itself was divided by similar parallel fringes of smaller dimensions, differing in number according to the distance at which the shadow was observed, but leaving the middle of the shadow always white. Now these fringes were the joint effects of the portions of light passing on each side of the slip of card, and inflected or rather diffracted into the shadow. For a little screen being placed either before the card or a few inches behind it, so as either to throw the edge of its shadow on the margin of the card, or to receive on its own margin the extremity of the shadow of the card, all the fringes which had before been observed in the shadow on the wall immediately disappeared, although the light inflected on the other side was allowed to retain its course, and although this light must have undergone any modification that the proximity of the other edge of the slip of card might have been capable of occasioning."

Dr Young's experiment.

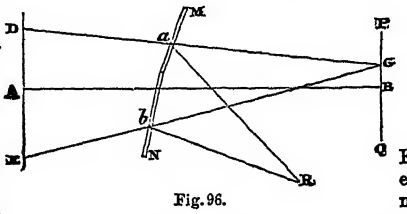


Fig. 96.

Fresnel's experiments.

Although this experiment is a very decisive one, yet M. Fresnel made one still more instructive and general, and free from any of the objections that might have been urged

[1] *Phil. Trans.* 1804; or *Elements of Nat. Phil.*, vol. ii., p. 639.

Periodical Colours.

against that of Dr Young. He took two plane mirrors MN (fig. 96), which were inclined at a very great angle, a little less than 108°, and having allowed a beam of light R*a*, R*b*, proceeding from a luminous point R, such as the focus of a small lens, he received the reflected rays on a piece of paper PQ. If the light was homogeneous, there was seen upon the paper a succession of bright and dark bands alternating. These bands are parallel to the line of intersection of the two mirrors, and they are placed symmetrically on both sides of a plane passing through the line of intersection of the mirrors, and through a point A bisecting the distance of the points D, E, the virtual points of divergence of the two reflected pencils *a*G, *b*G. That these parallel bands are produced by the mutual interference of the two beams is at once proved by intercepting one of them, or by covering one of the mirrors, when the whole series disappears. It is found also, by measuring the distances of the same bands from the line of intersection of the mirrors, and when the paper PQ is placed at different distances from the mirrors, that their different points lie in hyperbolas whose foci are D, E, and common centre A.

Dr Lloyd's experiment.

A still more simple and elegant method of exhibiting the phenomena of interference has been given by Dr Lloyd of Dublin, which any person may repeat with a single piece of plate-glass. Having placed horizontally a piece of black glass QP (fig. 97), with his eye behind it at QM, he viewed by very oblique reflection, when the angle of incidence was nearly 90°, a horizontal narrow aperture placed at A, a distance of 3 feet from the reflector QP. The proper degree of obliquity was easily found by bringing the reflected image of the aperture A to coincide very nearly with the direct image, in which case the direction of the reflected plane BPQ bisected the distance AA'. When the ray AM, which fell directly upon the eye at M, interfered with the reflected ray CM, which reached it by a longer path, they produced a system of fringes or bands, which were distinctly visible when received upon an eye-piece placed at a short distance from the reflector. This system of bands was exactly similar to one-half of the system seen in Fresnel's experiment. With compound white light the first band was a *bright* one and *colourless*. This was followed by a very sharply defined black band; then came a coloured one; and so on alternately, seven alternations being easily counted, and the breadth of the bands being, as near as the eye could judge, the same throughout the series, and increasing with the obliquity of the reflected beam.

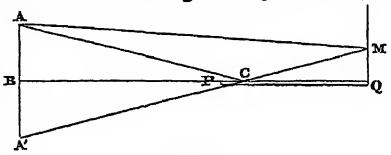


Fig. 97.

When homogeneous light is used, the bands are alternately bright and dark, and varying in magnitude with the refrangibility of the light, as will be afterwards more fully explained. If the light of the sun is used, the bands may be distinctly seen upon a white screen placed at MQ. That they are produced by interference may be easily proved either by stopping the direct ray AM, or the reflected one CM, when the whole system of bands disappears.

Newton's experiment.

The leading phenomena of interference may be likewise exhibited by transmitting the light emanating from a luminous point through the two faces of a prism the inclination of which is about 180°. The pencil or ray passing through one of the faces will be slightly inclined to the ray passing through the other at a small angle, and will interfere with it at their point of concourse, and produce the usual fringes. This form of the experiment is described by Sir Isaac Newton, who considered the fringes as produced by inflection.

Periodical Colours.

In all the preceding experiments, two pencils of light, issuing from the same point or luminous origin, are made again to meet, the one having arrived at the point of concourse by a different and a longer path. Now it is obvious from the experiments, that, when the two portions of light thus intervening reach the spot where they interfere by paths exactly equal, they form a bright fringe having the intensity of its light greater than that of either portion. It is also evident that other bright fringes are produced when their paths differ in length; and if we suppose d to be the difference of paths by which the second bright fringe is produced, similar bright fringes will be produced when the differences in the lengths of the paths are $2d$, $3d$, $4d$, $5d$, $6d$, &c. But it is manifest from the preceding experiments that if the two portions of light interfere at intermediate points, or when the difference in the length of their paths is $\frac{1}{2}d$; $d+\frac{1}{2}d$; $2d+\frac{1}{2}d$; $3d+\frac{1}{2}d$; $4d+\frac{1}{2}d$, &c., the two interfering portions *destroy each other* and produce blackness, as appears from the dark fringes lying between the bright ones. Here, then, we have a remarkable property of light established by direct experiment, and well fitted to guide us in our inquiries into the physical cause of the various phenomena of light. We shall find the same property showing itself under various aspects in a succession of interesting phenomena, which we shall now proceed to describe.

Sect. II.—On the Colours of Thin Plates.

Colours of thin plates.

The colours of thin plates were first observed by Mr Boyle, who remarks that all chemical essential oils, as also good spirits of wine, by shaking till they rise in bubbles, appear of various colours, which immediately vanish when the bubbles burst, so that a colourless liquor may be immediately made to exhibit a variety of colours, and lose them in a moment, without any change in its essential principles.

Boyle.

Mr Boyle also noticed these colours in soap-bubbles and in turpentine, and he succeeded in blowing glass sufficiently thin to exhibit them. In 1666 Lord Brereton observed similar colours produced by the thin plates which are formed on the surface of glass by the action of the weather.

Hooke.

In the year 1672 Dr Hooke exhibited to the Royal Society a soap-bubble with all its colours, in fulfilment of a promise which he had made at a previous meeting, "to exhibit something which had neither refraction nor reflection, and yet was diaphanous.... By means of a glass pipe he blew several small bubbles out of a mixture of soap and water, when it was observable that at first they appeared white and clear, but that after some time, the film growing thinner, there appeared upon it all the colours of the rainbow, first a pale yellow, then orange, red, purple, blue, green, with the same series of colours repeated." Dr Hooke made considerable progress in the investigation of this class of phenomena, and made experiments with thin plates of Muscovy glass (mica). He found that a faint yellow plate of this substance laid upon a blue one constituted a very dark purple; and Sir Isaac Newton,[1] in a private letter to Dr Hooke, acknowledges that Hooke had observed previous to him "the dilatation of the coloured rings by the obliquation of the eye, and the apparition of a black spot at the contact of two convex lenses, and at the top of a water-bubble."

Newton.

Sir Isaac Newton, whose investigations we shall presently give in his own words, made great progress in discovering the law of the phenomena; and it is a curious fact, not to be overlooked by physical inquirers, that his theory of the phenomena; elaborated with the utmost care, and generalizing an extensive series of facts, is now exploded, while the theoretical views of Dr Hooke are almost universally admitted.

Mr Melville of Edinburgh proposed to make a perma-

[1] Dated Cambridge, Feb. 5, 1675–6. (Brewster's *Memoirs, &c., of Newton*, vol. i.)

Periodical Colours.

nent soap-bubble by freezing, but we believe the experiment has never yet succeeded. Dr Joseph Reade has however been more fortunate in making what may be called a permanent soap-bubble for illustrating the colours of thin plates, which we saw him exhibit at the meeting of the Physical Section of the British Association at Liverpool in 1837. The following is his own account of the method of making it:—"Having put two ounces of distilled water into an eight-ounce phial, and having added about the size of a large pea of Castile soap, I placed the bottle in a saucepan of boiling water on the fire; the bottle was speedily filled with a dense volume of vapour, which expelled all the air. I now corked it, and after cooling and thus condensing the vapour, had perhaps as perfect a vacuum as could be formed, even by the best air-pump. I now held the bottle laterally between my hands, and by means of a circular and brisk motion formed a circular film, on which, by resting the bottle on an inclined plane, were formed after a short time all the parallel bands or series of colours in the following order:—1. A white or silvery segment at top; 2. a snuff-coloured brown, inclined at bottom to a deep red; 3. blue; 4. yellow; 5. red; 6. blue; 7. green; 8. red; 9. green; 10. red; 11 green (as at A, fig. 98).

Dr Reade's permanent soap-bubble.

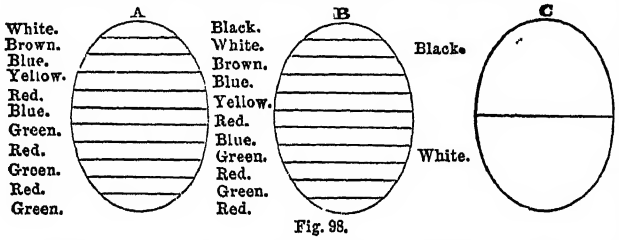


Fig. 98.

"After some time a black segment was seen to form at the top of the white, and continually to increase in size (fig. 98, B). After a few minutes the parallel bands increased in breadth, and running into one another, only three or four distinct bands were seen. Nothing can exceed the beauty of these colours, equal to those of the rainbow or the plumage of the tropics: whilst writing this description, I have these bands in a bottle before me, feasting my eyes on their beauty. In a few minutes more this black segment or aqueous film occupies, perhaps, half the circular film, and the lower half becomes white tinged with orange (fig. 98, C).

"If we now incline the bottle towards the experimenter's breast, the saponaceous atoms producing these colours are seen to float in the region of the black or aqueous; when placed again on the inclined plane, they fall to the bottom of the film. In some time more the entire film becomes black, and all the colours disappear.

"Having now placed the bottle in a basin of boiling water, the evaporation was increased, and the black film soon became clothed with saponaceous atoms, which being variously condensed, produced all the colours of the clouds when the sun is setting on a summer's evening. On again placing the bottle on the inclined plane, the parallel bands were again formed by the attraction of cohesion, and the colours afterwards gave place to the black film. I held the bottle laterally between my hands, and by means of a circular motion washed it, and thus clothed it with saponaceous atoms, which went through the same process on placing the bottle on the inclined plane. By means of washing the film every morning, I preserved it for more than three weeks."

Colours of thin plates exhibited in nature.

The colours of thin plates are often exhibited in nature in the most beautiful manner. On the surface of little pools of mossy water, and especially in the proximity of springs containing iron, we observe thin bright films generally whitish, and often yellow and reddish. Between the plates of a mass of mica, or sulphate of lime, or talc, we observe thousands of open spaces where the rings are sometimes circular, consisting only of the first tint above blackness,—viz., the white of the first order, sometimes two, three, or more colours, according to their size, while at other times the rings of fringes are extremely numerous and often irregular. These colours are all produced by thin plates of air or of vacuity in these fissile minerals, and the colours may be all changed by admitting water or fluids of different refractive powers. In some specimens of Labrador felspar Sir David Brewster has found crystallized cavities so thin, or with so little depth, as to give the most splendid colours of thin plates, and to afford one of the finest subjects of popular display in the microscope.[1] The colours produced by heat on highly-polished steel are all the colours of a thin plate of oxide; and they are often beautifully displayed on the sides and on the bars of grates.

Periodical Colours.

When glass is exposed to the action of the weather, its surface acquires a thin film, which at first can only be rendered visible by examining the faint light reflected from it when it is in contact with a fluid of nearly the same refractive power. It forms most rapidly on the panes of glass in stable windows, but it is seen in the highest perfection in the specimens of decomposed glass found among the remains of Roman buildings. The glass is to a certain depth entirely decomposed into thin films of extreme beauty, reflecting the most brilliant colours to the eye, and transmitting tints of the most exquisite brilliancy, and far surpassing any of the colours produced by art.[2] Coloured films of the richest tints are also seen upon both the faces of cleavage of a sort of artificial mother-of-pearl, which has been called *nacrite*, and described by Mr Horner in the *Phil. Trans.* These films are all thin plates of extreme tenuity.

Colours of decomposed glass.

When we breathe upon glass at a proper temperature, and examine with a magnifier the margin of the film while evaporating, or when we observe the evaporation of different volatile fluids, we shall perceive many interesting examples of the colour of thin plates.

Of vapour.

One of the finest exhibitions of this kind with which we are acquainted is that which is produced by the ammonio-sulphate of copper, and which was observed by Sir David Brewster. A solution of the ammonio-sulphate of copper in water is spread upon a clear plate of glass or any other surface. In the course of an hour or two a similarly coloured film is formed upon its surface, exhibiting the colours of thin plates from the white of the first order upwards. When the solution is strong, or the stratum of fluid deep, the thickness of the film increases, and the colours rise to higher orders of a beautiful green and pink colour. When the colours are such as we would wish to preserve, an aperture must be made in the film, and by inclining the plate the fluid must be allowed to run out slowly, leaving the film on the surface of the glass. This film will become hard and permanent after the aqueous part of it has been evaporated. The fringes of colour take the shape of the mass of fluid, or of the piece of glass whose surface is covered with it.

The ammonio-sulphate of copper.

One of the most extraordinary examples of the colours of thin plates, or rather of the blackness that immediately precedes these colours, and one which almost requires the evidence of ocular demonstration to credit, is the existence of filaments, or of a down of quartz so exceedingly minute as to be incapable of reflecting light. The very remarkable specimen of quartz in which this was discovered by Sir David Brewster belongs to the cabinet of the Duchess of Gordon. The original crystal was $2\frac{1}{4}$ inches in diameter,

Black fibres in quartz.

[1] *Edin. Trans.*, vol. xi., p. 322. [2] *Phil. Trans.* 1837, part ii. [3] Ibid. 1836, p. 49, and 1837, part ii.

Periodical Colours.

and of a light smoky colour, but impervious to light except in small pieces. Mr Sanderson, lapidary in Edinburgh, had broken up the crystal for the purposes of his profession, but the apparent foulness of the fracture induced him to lay it aside. The following is an account given by Sir David Brewster, of the principal fracture :—

"At first sight, the absolute blackness of the separated surfaces seemed to me, as it did to every one, to be owing to a thin film of opaque and minutely divided matter that had insinuated itself into a fissure of the crystal; but this opinion was immediately overturned when I observed that both surfaces were equally and uniformly black, and that they were also perfectly transparent by transmitted light.

"Although I had now no doubt that the phenomenon was entirely of an optical nature, and that the blackness of the surfaces arose from their being composed of short and slender filaments of quartz, whose diameter was so exceedingly small that they were incapable of reflecting a single ray of the strongest light, yet it became desirable to establish this curious fact by experimental evidence.

"Having found that no detergent substances either removed or diminished the superficial blackness, I subjected the fragment to the action of cold and hot acids; but the surface continued unaltered by these operations. I now immersed the fragment in oil of anise seed, which approaches to quartz in its refractive power, and upon examining the light reflected at the separating surfaces of the oil and the quartz, I found that the blackness disappeared, and that the fragment, whether seen by reflected or transmitted light, comported itself like any other piece of quartz of the same translucency. Upon removing the oil from the surfaces, it resumed its original blackness, and the filamentous or velvety nature of the surface was rendered evident to the eye by the slight change of tint which was produced by pressing the filaments to one side."

Colours of thin plates between lenses.

The colours of thin plates may also be exhibited by pressing together two glass prisms that have moderate refracting angles. Various coloured fringes or portions of coloured rings will be seen by viewing the light reflected from the surfaces in contact, and, in a much fainter degree, by examining the transmitted light. The same phenomena may be seen with unusual brilliancy by taking a thick piece of glass, and having made a scratch on one side of it with a file, apply a heated wire to the scratch, so as to produce a crack in the glass, which may be extended at pleasure by a second and third application of the hot wire. If we now examine the surface of this crack in different directions, we shall see it covered with coloured fringes, which may be made to vary in breadth and position, by opening or closing the crack with the force of the hand.

When we wish to examine and measure the coloured rings with care, the method used first by Hooke, and subsequently by Newton, should be adopted. Two convex lenses of very long focal length are placed the one above the other, so as to touch at their vertex; or a plano-convex lens may have its plane side AB laid upon the convex side CD (fig. 101) of another lens. Sir Isaac Newton used for the uppermost lens a plano-convex one, whose focal length was fourteen feet, and for the lowermost a double convex lens, whose focal length was fifty feet. These lenses must then be held together, and pressed, if necessary, by three clamp screws, as shown in fig. 99. The following is the general account of the phenomenon given by Sir Isaac Newton, though somewhat abridged :—

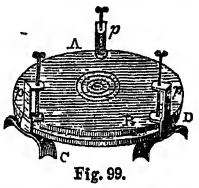


Fig. 99.

"Next to the pellucid central spot made by the contact of the glasses, succeeded *blue, white, yellow,* and *red.* The blue was so little in quantity, that I could not distinguish any violet in it, but the *yellow* and *red* were as copious as the *white,* though four or five times more than the *blue.* The next order of colours round those in the *second* was *violet, blue, green, yellow,* and *red,* all of them copious and vivid except the green. The *third* order was *purple, blue, green, yellow,* and *red,* the green being more vivid than in the last order. The *fourth* order was only *green* and *red;* the green being copious and lively, being bluish on one side, and yellowish on the other: the red was very imperfect. The succeeding rings or orders of colours were very faint; and after three or four orders, they ended in perfect whiteness. The form of the whole system of rings, when the lenses were most compressed, so as to produce the black spot in the centre, as shown in fig. 100, where *a, b, c, d, e; f, g, h, i, k; l, m, n, o, p;*

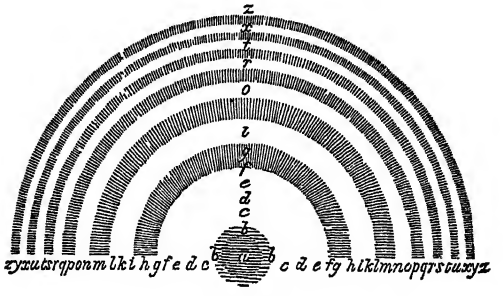


Fig. 100.

q, r; s, t; v, x; y, z, indicate the different colours beginning at the centre, viz.—1. *black, blue, white, yellow, red;* 2. *violet, blue, green, yellow, red;* 3. *purple, blue, green, yellow, red;* 4. *green, red;* 5. *greenish blue, red;* 6. *greenish blue, pale red;* 7. *greenish blue, reddish white.*

In order to find the interval between the glasses, or the thickness of the plate of included air (or space) at which each colour was produced, Sir Isaac measured the diameter of the first six rings at their brightest part, and found their squares to be in the arithmetical progression of the odd numbers 1, 3, 5, 7, 9, &c., and the intervals between the glasses are obviously in the same progression, one of the surfaces being plane, and the other spherical. He then measured the diameter of the rings at their darkest points, and found their squares to be in the arithmetical progression of the even numbers 2, 4, 6, 8, 10, &c.

In order to find the absolute thickness of the plate of air or space at which these different rings were produced, he measured the diameter of the fifth ring at its darkest point as produced by the different object-glasses.

Diameter of Sphericity of the object-glass.	Diameter of fifth dark ring.
182 inches	$\frac{100}{1774784}$
184 inches	$\frac{5}{88850}$

And dividing these diameters by 5, we obtain the diameter of the first ring $\frac{1}{88739}$ and $\frac{1}{88850}$; but as these measurements were taken at an angle of incidence of 4°, the results must be diminished in the ratio of the secant of 4°, or 10029, so that we have $\frac{1}{88952}$ and $\frac{1}{89063}$, the mean of which, $\frac{1}{89000}$ nearly expresses, in parts of an inch, *the thickness of the air at the darkest part of the first dark ring at a perpendicular incidence.*

By multiplying this interval by the series of odd and even numbers, 1, 3, 5, 7, &c., and 2, 4, 6, and 8, &c., we obtain the following measures of all the rings :—

Periodical Colours.

	Thickness of the air at the brightest part.	Thickness of the air at the darkest part.
First Ring,	$\frac{1}{178000}$	$\frac{2}{178000}$ or $\frac{1}{89000}$
Second Ring,	$\frac{3}{178000}$	$\frac{4}{178000}$ or $\frac{2}{89000}$
Third Ring,	$\frac{5}{178000}$	$\frac{6}{178000}$ or $\frac{3}{89000}$
Fourth Ring,	$\frac{7}{17800}$	$\frac{8}{178000}$ or $\frac{4}{89000}$

Effects of oblique incidence.

After measuring the diameters of the rings at different angles of incidence, Sir Isaac obtained the following results:—

Angle of Incidence on the Air.	Angle of Refraction into the Air.	Diameter of the Ring.	Thickness of the Air.
Degr. min.	Degr.		
0 0	0	10	10
6 26	10	$10\frac{1}{7}$	$10\frac{2}{7}$
12 45	20	$10\frac{1}{3}$	$10\frac{2}{3}$
18 49	30	$10\frac{3}{4}$	$11\frac{1}{2}$
24 30	40	$11\frac{2}{3}$	13
29 37	50	$12\frac{1}{2}$	$15\frac{1}{2}$
33 58	60	14	20
35 47	65	$15\frac{1}{4}$	$23\frac{1}{4}$
37 19	70	$16\frac{2}{3}$	$28\frac{1}{4}$
38 33	75	$19\frac{1}{4}$	37
39 27	80	$22\frac{2}{3}$	$52\frac{1}{4}$
40 0	85	29	$84\frac{1}{13}$
40 11	90	35	$122\frac{1}{2}$

From these measures, Newton inferred that the diameter of the rings increased with the obliquity of incidence, and he inferred that the thickness of the plate of air at which the same colour was produced was proportional to the sine of an angle whose sine had to the sine of the angle of incidence the constant ratio of $\frac{106+\frac{1}{m}}{107}$, m being the index of refraction. MM. Provostaye and Desains have, however, found that the thickness is simply proportional to the secant of the angle of incidence, as indicated by the undulatory theory.[1]

Periodical Colours.

Sir Isaac next proceeds to describe the rings formed by the light transmitted through the two glasses. In this system of transmitted rings, the order of the colours was *yellowish red; black, violet, blue, white, yellow, red; violet, blue, green, yellow, red.* The colours in these rings are very faint at a perpendicular incidence, but become brighter as the incidence increases.

Rings by transmitted light.

In fig. 101, Sir Isaac has represented the different colours reflected and transmitted, AB and CD being the surfaces of the glasses which touch at E, and the lines uniting them representing their distances in arithmetical progression. The words above the straight line AB are the colours of the *reflected* rings, and those below the circular arch CD those of the *transmitted* rings.

When water was introduced between the lenses, the colours became fainter, and the rings less, and Sir Isaac

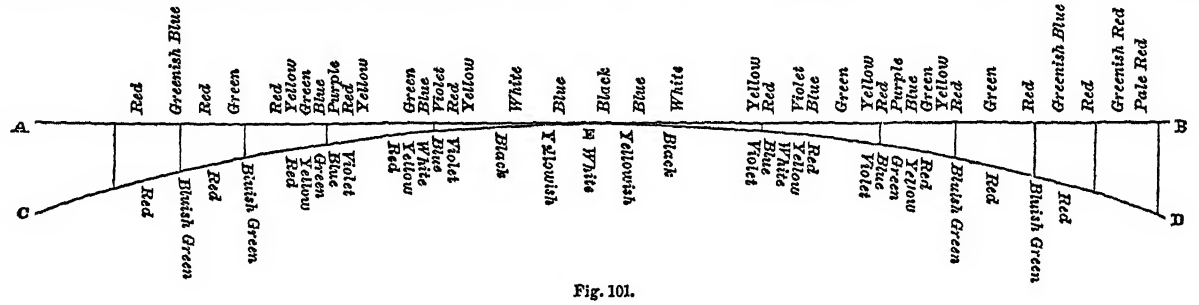


Fig. 101.

found that the intervals were inversely as the indices of refraction in water and air.

The rings were always larger in the homogeneous *red* light of the spectrum than in the *violet* light, in the ratio of $14\frac{1}{2}$ to 9; and he concluded, from more detailed observations, that the thicknesses of the air between the glasses when the rings were successively formed by the limits of the seven different colours, *red, orange, yellow, green, blue, indigo,* and *violet,* are to one another as the cube roots of the squares of the eight lengths of a cord which sound the notes in an eighth, *sol, la, fa, sol, la, mi, fa, sol,* that is, in the cube roots of the squares of the numbers 1, $\frac{8}{9}$, $\frac{5}{6}$, $\frac{3}{4}$, $\frac{2}{3}$, $\frac{3}{5}$, $\frac{9}{16}$, $\frac{1}{2}$; or 1, 0·924, 0·885, 0·825, 0·763, 0·711, 0·681, 0·630; that is, if 1 be the interior diameter of any such red ring formed by the extreme red rays, the cube root of $\frac{3}{5}$ will be the interior diameter of a ring at the boundary of the red and orange, and so on.[2]

Colours of soap-bubbles.

The colours of thin plates of fluid or solid bodies are not so easily studied as those of air, from the difficulty of procuring, and working with, such evanescent films. Sir Isaac Newton, however, studied them in soap-bubbles, which, as soon as they were blown, he covered with a clear glass. In this way he observed the colours to emerge like so many concentric rings surrounding the summit of the bubble. As the bubble became thinner, by the subsidence and evaporation of the water, the rings dilated slowly, till they covered the whole bubble, descending in order to the bottom of it, where they vanished successively. After all the colours had emerged at the top, there grew in the centre of the rings a small round black spot, which continually dilated itself till it became sometimes more than a half or three quarters of an inch in breadth before the bubble broke. Some light was still reflected from the water at this spot, and Sir Isaac saw within it several smaller round spots much blacker than the rest, but still capable, like the larger one, of reflecting faintly an image of the sun.

By observing how much the colours at the same places of the bubble, or at divers places of equal thicknesses, were varied by the several obliquities of the rings, Sir Isaac obtained the following thicknesses of the water requisite to exhibit one and the same colour at several obliquities:—

Incidence on the Water.	Refraction into the water.	Thickness of the water.
0°	0° 0′	10
15	11 11	$10\frac{1}{4}$
30	22 1	$10\frac{3}{4}$
45	32 2	$11\frac{1}{4}$
60	40 30	13
75	46 25	$14\frac{1}{2}$
90	48 35	$15\frac{1}{4}$

These results harmonize entirely with the rule already given for thin plates of air.

When the system of rings seen by reflection was examined by a prism, and perhaps only eight rings visible, Sir Isaac counted sometimes more than forty on the side of the sys-

[1] *Comptes Rendus*, 1850, tom. xxx., p. 498.

[2] It has been noticed by M. Le Blanc, that if the two extreme terms of the preceding numbers, or any other two equidistant from the extremes, be multiplied together, their product will always be equal to $\frac{1}{2}$.

Periodical Colours.

tem to which the refraction was made, though he reckoned by estimation more than a hundred. Soap-bubbles also, before they exhibited any colours to the naked eye, have appeared through a prism girded about with many parallel and horizontal rings, to produce which effect it was necessary to hold the prism parallel, or very nearly parallel, to the horizon, and to dispose it so that the rings might be refracted upwards.

Solid bubbles.

By mixing a little sugar with the solution of soap, we may blow bubbles of a very large size, which exhibit the coloured zones in the most perfect manner. If we place one of these bubbles, when blown, near a fire, so as to evaporate the water, the bubble upon bursting becomes solid, and falls down in coloured fragments, which are thin films of sugar and soap.

Iriscope.

An excellent method of showing the colours of thin plates of a solid body, is with a simple apparatus to which Dr Joseph Reade has given the name of *Iriscope*. This instrument consists of a plate of highly polished black glass, having its surface smeared with a solution of fine soap, and subsequently dried by rubbing it clean with a piece of chamois leather. If we now breathe upon the glass surface through a glass tube, the vapour will be deposited on the glass, and produce brilliantly-coloured concentric rings, the outermost of which is black, while the interior ones have various colours, or no colour at all, according as a greater or a less quantity of vapour has been deposited. The colours in these rings, when seen by common light, correspond with Newton's reflected rings, about to be described, or those which have black centres; the only difference being, that in the plate of soapy vapour, which is the thickest in the middle, the rings in the iriscope have black circumferences.[1] Very beautiful phenomena of this kind may be observed by laying thin films of fluids upon the surfaces of fluid or solid bodies, or by stretching similar films of various oils, such as *oil of laurel, oil of cassia, oil of turpentine*, &c., across circular apertures, such as rings made of wires. The coloured tints and other phenomena exhibited by these attenuated films are very remarkable. With oils of cinnamon, naphtha, spearmint, wormwood, rape-seed, poppies, nutmegs, bergamot, savine, rosemary, &c., the phenomena are peculiarly beautiful.[2]

Films on metals.

The colours of thin plates of solid bodies are finely displayed in the films of oxide formed upon plates of lead, and in the films of certain oxides or salts deposited on the surface of metals by the voltaic pile. The method of depositing such films on plates of steel plunged in acid solutions, and of producing the beautiful chromatic designs which he executed, was discovered by Professor Nobili of Reggio.

Films of decomposed glass.

The colours of thin solid films are displayed with singular beauty in the scales of decomposed glass that have been found among the ruins of Assyrian, Greek, and Roman buildings. The silex and alkali which form glass have been placed by fusion in a state of unnatural constraint, and the particles of each have a tendency to recombine. The action of moisture, or of air charged with ammonia or other bodies, assists the particles which compose the glass in separating from each other. The glass becomes opaque on its two surfaces, and the opacity gradually advances inward till the whole of the glass is decomposed. In this state it breaks with the slightest force, like the thinnest slice of an apple. In other cases the decomposition begins at a variety of centres, where, from some cause or other, the particles have been less firmly coherent; and it goes on in concentric spheres, separating the glass into thin films of a spherical form, and of surpassing beauty in point of colour. The decompositions round two or more centres often unite, and go on in rings surrounding the centres in question. In stable windows, or in glass that has been long in salt water, the decomposition into coloured scales takes place most quickly. In the specimens of decomposed glass from Rome and from Nineveh, which the writer of this article received from the late Marquis of Northampton and Mr Layard, centuries have been required to effect the decomposition.[3]

Periodical Colours.

Composition of the colours of thin plates.

Sir Isaac then proceeds to a very important part of the subject,—namely, to explain the composition of the colours of thin plates, a topic of great interest and extensive application: "Let there be taken," says he, "on any right line from the point Y (fig. 102), the lengths YA, YB, YC, YD, &c in the proportion of the numbers, 6300, 6814, 7114,

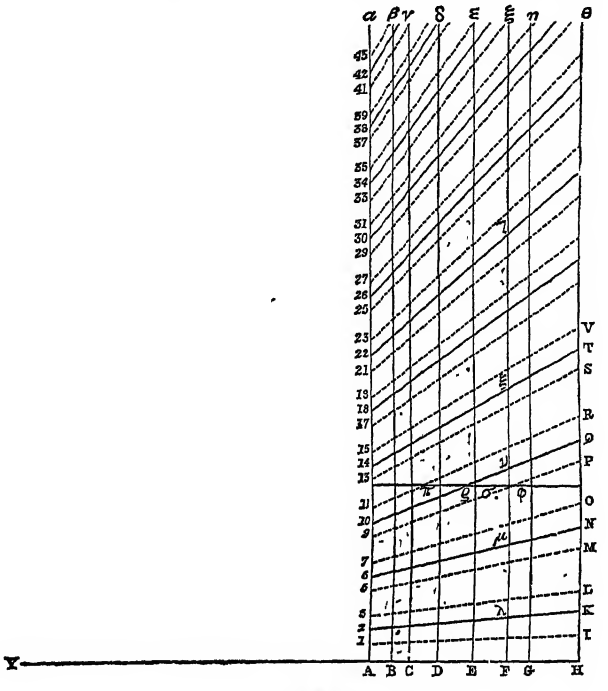


Fig. 102.

8255, 8855, 9243, 1000; and at the points A, B, C, D, E, F, G, &c., let perpendiculars Aα, Bβ, Cγ, &c., be erected, by whose intervals the extent of the several colours set underneath against them is to be represented. Then divide the line Aα in such proportions as the Nos. 1, 2, 3, 5, 7, 9, &c., set at the points of division, denote, and through these divisions from Y draw lines 1I, 2 K, 3L, 5M, 6N.

"Now, if A2 be supposed to represent the thickness of any thin transparent body, of which the internal violet is most copiously reflected on the first ring, then HK will represent its thickness at which the outermost red is most copiously reflected in the same series. Also A6 and HN will denote the thicknesses at which those extreme colours are most copiously reflected in the second series, and A10 and HQ the thicknesses at which they are most copiously reflected in the third series; and so on. And the thickness at which any of the intermediate colours are reflected most copiously, will be defined by the distance of the line AH from the intermediate parts of the lines 2K, 6N, 10Q, &c., against which the names of those colours are written below.

"But, farther, to define the latitude of these colours in each ring or series, let A1 be the least thickness and A3 the greatest thickness, at which the extreme violet in the first series is reflected, and let HI and HL be the like limits for the extreme red, and let the intermediate colours be limited by the intermediate parts of the lines 1I, 3L, against which the names of those colours are written; and so on. But yet with this caution, that the reflections be supposed strongest at the intermediate spaces, 2K, 6N,

[1] See *Phil. Trans.* 1841, p. 43. [2] Ibid. 1841, p. 53 and note. [3] Brewster's *Treatise on Optics*, p. 119.

Periodical Colours.

10Q, &c., and from thence to decrease gradually towards these limits, 1I, 3L, 5M, 7O, &c., on either side; where you must not conceive them to be precisely limited, but to decay indefinitely. And whereas I have assigned the same latitude to every series; I did it, because although the colours in the first series seem to be a little broader than the rest, by reason of a stronger reflection there, yet that inequality is hardly sensible.

"Now, according to this description, conceiving that the rays, originally of several colours, are by turns reflected at the spaces 1I, L3, 5M, O7, 9P, R11, &c., and transmitted at the spaces AHI1, 3LM5, 7OP9, &c., it is easy to know what colour must in the open air be exhibited at any thickness of a transparent thin body. For, if a ruler be applied parallel to AH, at that distance from it by which the thickness of the body is represented, the alternate spaces 1IL3, 5MO7, &c., which it crosseth, will denote the reflected original colours, of which the colour exhibited in the open air is compounded. Thus, if the constitution of the green in the third series of colours be desired, apply the ruler as you see at $\pi\rho\sigma\varphi$, and by its passing through some of the blue at π, and yellow at σ, as well as through the green at ρ, you may conclude that the green exhibited at that thickness of the body is principally constituted of original green, but not without a mixture of some blue and yellow.

"By this means you may know how the colours from the centre of the outward rings ought to succeed in order as they were described. For, if you move the ruler gradually from AH through all distances, having passed over the first space which denotes little or no reflection to be made by the thinnest substances, it will first arrive at 1 the violet, and then very quickly at the blue and green, which, together with that violet, compound blue, and then at the yellow and red, by whose farther addition that blue is converted into whiteness, which whiteness continues during the transit of the edge of the ruler from I to 3, and after that, by the successive deficiency of its component colours, turns first to compound yellow, and then to red, and last of all the red ceaseth at L. Then begin the colours of the second series, which succeed in order during the transit of the edge of the ruler from 5 to O, and are more lively than before, because more expanded and severed. And for the same reason, instead of the former white there intercedes between the blue and yellow a mixture of orange, yellow, green, blue, and indigo, all which together ought to exhibit a dilute and imperfect green. So the colours of the third series all succeed in order; first, the violet, which a little interferes with the red of the second order, and is thereby inclined to a reddish purple; then the blue and green, which are less mixed with other colours, and consequently more lively than before, especially the green: Then follows the yellow, some of which towards the green is distinct and good, but that part of it towards the succeeding red, as also that red, is mixed with the violet and blue of the fourth series, whereby various degrees of red, very much inclining to purple, are compounded. The violet and blue, which should succeed this red, being mixed with, and hidden in it, there succeeds a green. And this at first is much inclined to blue, but soon becomes a good green, the only unmixed and lively colour in this fourth series. For as it verges towards the yellow, it begins to interfere with the colours of the fifth series, by whose mixture the succeeding yellow and red are very much diluted and made dirty, especially the yellow, which, being the weaker colour, is scarce able to show itself. After this the several series interfere more and more, and their colours become more and more intermixed, till, after three or four more revolutions (in which the red and blue predominate by turns) all sorts of colours are in all places pretty equally blended, and compound an even whiteness.

Periodical Colours.

"And since the rays endued with one colour are transmitted, where those of another colour are reflected, the reason of the colours made by the transmitted light is from hence evident.

"If not only the order and species of these colours, but also the precise thickness of the plate, or thin body at which they are exhibited, be desired in parts of an inch, that may be also obtained by the assistance of the preceding observations. For, according to these observations, the thicknesses of the thinned air, which between two glasses exhibited the most luminous parts of the first six rings, were

$$\frac{1}{178000}, \frac{3}{178000}, \frac{5}{178000}, \frac{7}{178000}, \frac{9}{178000}, \frac{11}{178000}$$ parts of an inch.

Suppose the light reflected most copiously at these thicknesses be the bright citrine yellow, or confine of yellow and orange, and these thicknesses will be $F\lambda$, $F\mu$, $F\xi$, Fo, $F\tau$. And this being known, it is easy to determine what thickness of air is represented by $G\varphi$, or by any other distance of the ruler from AH.

"On these grounds I have composed the following table, wherein the thickness of air, water, and glass, at which each colour is most intense and specific, is expressed in millionth parts of an inch.

The Thickness of Coloured Plates and Particles of Air, Water, and Glass.

	Reflected Tints.	Transmitted Tints.	Air.	Water.	Glass.
Their colours of the *first* order.....	Very black	...	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{10}{21}$
	Black	White.....	1	$\frac{3}{4}$	$\frac{20}{21}$
	Beginning of black.....	...	2	$1\frac{1}{2}$	$1\frac{3}{7}$
	Blue	Yellowish red	$2\frac{3}{5}$	$1\frac{7}{8}$	$1\frac{11}{16}$
	White	Black	$5\frac{1}{4}$	$3\frac{7}{8}$	$3\frac{3}{7}$
	Yellow	Violet.....	$7\frac{1}{2}$	$5\frac{1}{4}$	$4\frac{3}{7}$
	Orange	...	8	6	$5\frac{1}{7}$
	Red	Blue	9	$6\frac{3}{4}$	$5\frac{1}{4}$
Of the *second* order.....	Violet	White.....	$11\frac{1}{2}$	$8\frac{3}{8}$	$7\frac{1}{7}$
	Indigo	...	$12\frac{3}{5}$	$9\frac{3}{8}$	$8\frac{2}{7}$
	Blue	Yellow.....	14	$10\frac{1}{2}$	9
	Green	Red.....	$15\frac{1}{2}$	$11\frac{1}{2}$	$9\frac{3}{4}$
	Yellow	Violet.....	$16\frac{3}{4}$	$12\frac{1}{2}$	$10\frac{2}{7}$
	Orange	...	$17\frac{3}{5}$	13	$11\frac{1}{7}$
	Bright red.....	Blue	$18\frac{1}{2}$	$13\frac{3}{4}$	$11\frac{4}{7}$
	Scarlet	...	$19\frac{3}{5}$	$14\frac{3}{4}$	$12\frac{3}{7}$
Of the *third* order	Purple	Green.....	21	$15\frac{3}{4}$	$13\frac{13}{28}$
	Indigo	...	$22\frac{3}{10}$	$16\frac{1}{2}$	$14\frac{1}{7}$
	Blue	Yellow.....	$23\frac{3}{5}$	$17\frac{1}{2}\frac{1}{6}$	$15\frac{1}{14}$
	Green	Red.....	$25\frac{1}{2}$	$18\frac{9}{10}$	$16\frac{1}{7}$
	Yellow	...	$27\frac{1}{4}$	$20\frac{1}{4}$	$17\frac{1}{7}$
	Red	Bluish green	29	$21\frac{3}{4}$	$18\frac{4}{7}$
	Bluish red	...	32	24	$20\frac{4}{7}$
Of the *fourth* order.....	Bluish green ...	...	24	$25\frac{1}{2}$	22
	Green	Red.....	$35\frac{2}{7}$	$26\frac{1}{2}$	$22\frac{4}{7}$
	Yellowish green	...	36	27	$23\frac{1}{7}$
	Red	Bluish green	$40\frac{1}{2}$	$30\frac{1}{4}$	26
Of the *fifth* order.....	Greenish blue...	Red.....	46	$34\frac{1}{2}$	$29\frac{1}{7}$
	Red	...	$52\frac{1}{2}$	$39\frac{3}{8}$	34
Of the *sixth* order	Greenish blue...	...	$58\frac{3}{4}$	44	38
	Red	...	65	$48\frac{3}{4}$	42
Of the *seventh* order.....	Greenish blue...	...	71	$53\frac{1}{4}$	$45\frac{5}{7}$
	Ruddy white	...	71	$57\frac{3}{4}$	$49\frac{3}{7}$

In a paper on the colours of thin plates,[1] M. Arago has

[1] *Mém. d'Arcueil.*

Periodical Colours.

M. Arago.

given an account of some important discoveries on this subject. In viewing the reflected rings through a rhomb of Iceland spar, having its principal section parallel or perpendicular to the plane of incidence, he observed that the intensity of light in one of the images varied with the angle of incidence, and that this image vanished at an incidence of 35°, the maximum polarizing angle for glass. He discovered the very same property in the transmitted rings. He found also that when the reflected and the transmitted systems of rings are superposed, they completely neutralize each other, forming white light; and hence he concluded that their colours were complementary, and the intensities of their illumination equal.

M. Arago next examined the system of rings when formed between a lens and a metallic reflector. When he observed them with the rhomb of spar, one of the images vanished as formerly at 35° of incidence, the *angle of maximum polarization of glass;* but *above* and *below* that angle he observed the most singular phenomena. At incidences *below* 35° the two images formed by the doubly-refracting rhomb differed only in intensity, the colours and the diameters of the rings being exactly the same in both. *Above* the polarizing angle, however, the rings in the two images were of complementary tints, the orders of colours in the one beginning from a black centre, and in the other from a white centre. M. Arago also observed that the rings of the same order of colours in the two images had different sizes.

Mr Airy.

Dr Lloyd.

Without knowing of these discoveries of M. Arago, Mr Airy,[1] about twenty years afterwards, published similar results respecting the modification of the rings above and below the maximum polarizing angle; and Dr Lloyd has ingeniously observed that an analogous result "may be obtained by combining, as in Fresnel's experiment (fig. 96), a metallic reflector with one of glass. The light being polarized perpendicularly to the plane of reflection, the central band will be white, when the angle of incidence is below the polarizing angle of the glass. At the polarizing angle the interference bars will vanish altogether; and beyond that incidence they will reappear with a *dark* centre in place of a white one. This method of observation would seem to be peculiarly adapted to the investigation of the change of phase produced by metallic reflection at various incidences."[2]

A consideration of Fresnel's expressions, which had led Mr Airy to make his experiments with a metallic surface, led him also to expect that when the rings were formed between two transparent surfaces of different refractive powers, and when the light was polarized perpendicularly to the plane of incidence, the rings should be *black-centred* at incidences below the maximum polarizing angle of the least refractive surface, or greater than that of the highest refractive surface, and should be *white*-centred when the angle of incidence was between these angles. By forming the rings between plate-glass and diamond, Mr Airy found his anticipations correct. In the course of these experiments he observed that the rings did not disappear at the polarizing angle of diamond, but that the first black ring contracted as the incidence was gradually increased, and at last took the place of the central white spot. Hence he concluded that there is still some light reflected at the maximum polarizing angle of diamond, and that this body has no angle of complete polarization. (See *History*, p. 550, col. 1.)

Periodical Colours.

Sir David Brewster.

This interesting subject was studied by Sir David Brewster in 1840, and the results communicated to the Royal Society of London in 1841. Our limits will permit us only to give the following general expression of the facts which he observed:—

"When two polarized pencils, reflected from the surfaces of a thin plate lying on a reflecting surface of a different refractive power interpose, *half an undulation is not lost, and white-centred rings are produced*, provided the mutual inclination of their planes of polarization is *greater than* 90°. When this inclination is *less than* 90°, *half an undulation is lost*, and *black-centred rings are produced.* When the inclination is *exactly* 90°, the pencils do not interfere, and *no rings* are produced."[3]

M. Jamin.

M. Jamin has very recently observed some interesting phenomena of the colours of thin plates when the reflected rings are formed between two prisms, and illuminated with the light of the spectrum. When the angle of incidence increases, the rings enlarge, and undergo a singular change. Each dark ring has in contact with it, *externally* if it is *violet*, a very brilliant fringe, and *internally* if it is *red*. As the angle of incidence increases, there arises in the bright and very wide space which separates two dark rings, obscure lines, which are all bordered with a brilliant fringe, and have the same appearance as the principal ring. Complementary phenomena are seen in the transmitted rays. These phenomena disappear only at the angle of total reflection; but when the angle of incidence is very near the angle of total reflection, there is an instant when the reflected and transmitted rings are so enlarged that they go out of the field of vision, and there are now seen a considerable number of new bright and dark fringes, produced at thicknesses of the thin plate of air too small for producing the ordinary rings. M. Jamin remarks that the theory does not afford any certain explanation of these fringes.[4]

Sect. III.—On the Diffraction or Inflection of Light.

Diffraction of light.

Fringes without the shadow.

M. Grimaldi, to whom we owe the discovery of the interference of light, likewise made some important experiments on what is called the diffraction or inflection of light. Having admitted a ray of solar light into a dark room, through a small hole AB (fig. 103), he placed in the conical beam ABCD an opaque body EF. The shadow of this body was not bounded by the straight lines AEH, BFG, nor by the penumbra IL formed by the lines BEL, AFI,

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[1] *Cambridge Transactions*, 1832. The following note upon this paper we confess ourselves unable to understand:—"I have carefully verified," says Mr Airy, "this assertion (that it is indifferent whether the light is polarized before or after reflection), because I think that it leads to important theoretical conclusions. If polarization were a *modification* of light (as Dr Brewster and others have supposed), it might be conceived that polarization before incidence might destroy its power of producing rings at a certain angle, or might change the tints; but when the reflection is performed, and the rings are actually visible to the eye with a dark centre, it seems quite inconceivable that any *modification* or *physical change* in the light should make that centre appear white. The satisfactory explanation is, that polarization is a *resolution* of the vibrations into two sets at right angles to each other, performed in such a manner that the two sets can in general be separately exhibited, and that in this instance only one is transmitted to the eye." The authors criticized in the preceding extract,—viz., Malus, Young, Biot, Herschel, and we believe MM. Arago and Fresnel, all considered polarization as a modification of common light, and if a *modification*, certainly a *physical change* without any reference to theory. In every point of view, indeed, the term is philosophical and unexceptionable. If polarization is a *resolution*, as Mr Airy affirms, of vibrations *in an infinite number of planes*, into *two sets at right angles to each other*, which we do not question, this is certainly a pretty considerable modification, and a very remarkable physical change. As we have nothing to do with theories in describing phenomena, we must continue to use the terms which have been regarded as appropriate by our contemporaries.

[2] "Report on Optics," *British Association Reports*, Rep. 4, 1836, p. 366.

[3] "On the phenomena of thin plates of solid and fluid substances exposed to polarized light," *Phil. Trans.* 1841, p. 43.

[4] See *Comptes Rendus*, &c., 1852, tom. xxxv., p. 14.

Periodical Colours.

but was enlarged to MN, and was much greater than it should have been if formed by rays passing in straight lines

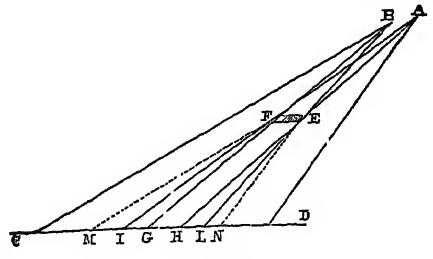

Fig. 103.

past the edges of the body. Without the shadow of the body there were three fringes of coloured light, the broadest and most luminous of which, next to the shadow X (fig. 104), was MNO. There was no colour in the middle at

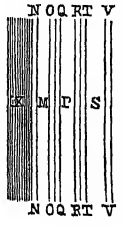

Fig. 104.

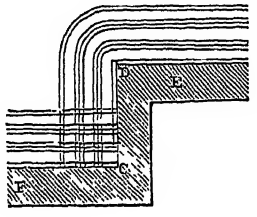

Fig. 105.

M; but it was *blue* at the side NN, and *red* at the other side OO. The second fringe PQR was narrower than MNO. It was colourless in the middle at P, faintly blue at QQ, and faintly red at RR. The third fringe STV resembled the other two, but was the narrowest and the faintest in its colours. They were bent round the edges of the body, as shown in fig. 105.

Fringes within the shadow.

Grimaldi likewise discovered fringes within the shadow, which were best seen when the body was long, the light great, and the distance from the aperture considerable. These internal fringes increased with the breadth of the body, and they became narrower when they increased in number. They were bent round the angles of the body, as shown in fig. 106, where ADBC is the shadow, and *a*, *b*, *c*, *d* the internal fringes. Short lucid streaks were seen proceeding, as it were, from the angle D, and returning to it, as shown in the figure.

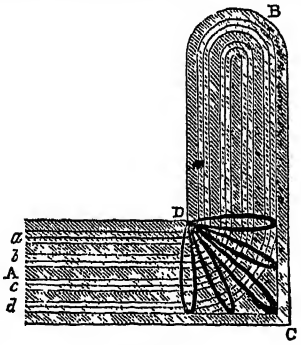

Fig. 106.

What Dr Young has called the *crested fringes* of Grimaldi are shown in fig. 107. These fringes are formed by any body that has a rectangular termination. At the line which bisects the right angle there is a white central fringe, bounded by hyperbolic curves, whose asymptotes are the diagonal line; and on each side of this are two or three other bands, disposed in hyperbolic curves, which are convex to the diagonal, and converging in some degree as they recede from the angular point.

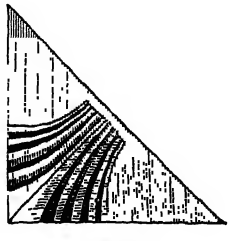

Fig. 107.

When the diffracting body tapers like the point of a very fine needle, Sir D. Brewster observed some interesting phenomena, which will be understood from fig. 108, which very imperfectly represents the internal and external fringes as produced by a needle-point like MN. The external fringes are represented by *mn*, *m'n'*, and are convex outwards, or parallel to the sides of the point MN. The *internal* fringes, as seen by Grimaldi and Dr Young, are shown by the deep black lines between A and B. These internal fringes, however, were observed to extend far beyond the shadow in fine hyperbolic curves, as shown between *o* and *p*, and *o'* and *p'*. These *internal* fringes intersect the *external* ones, and give them the appearance of screws or twisted cords. In homogeneous light, where the fringes are alternately dark and coloured, the dark fringes are dark at their intersections, and the coloured ones coloured. When the needle-point is illuminated by the spectrum, and the fringes viewed by a lens, which is necessary to see them, we require to approach the lens to the fringes *m'n'* on the *violet* side of the spectrum, and to withdraw it on the *red* side, in order to see them distinctly. When this experiment is made with great care, *twenty* external fringes may be counted on each side of the shadow, which may always be seen most distinctly by looking through the margin of the lens. When the diffracting body is an exceedingly small one with parallel sides, the *internal* fringes extend far beyond the shadow, mingling with the external ones, and completely altering their colours and forms.

Periodical Colours.

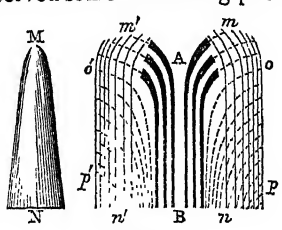

Fig. 108.

The *internal* fringes beyond the shadow, like those in it, disappear by intercepting the light with a screen on the opposite side of the diffracting body.

Sir Isaac Newton.

In repeating the experiments of Grimaldi, Sir Isaac Newton admitted the sun's light through a small hole in a piece of lead the forty-second part of an inch in diameter; he found the breadth of the shadow of a human hair, which was the 280th of an inch in diameter, to be as follows:—

Distance of the hair from the aperture.	Distance of the paper receiving the shadow from the hair.	Breadth of the shadow.
12 feet.....	4 inches.....	0·01666 inches.
12 „	24 „	0·03572 „
12 „	128 „	0·125 „

Upon comparing the breadths of the fringes without the shadow, and their intervals at different distances, he found them to be nearly in the same proportion, the breadths of the fringes being as the numbers 1, $\sqrt{\frac{1}{3}}$, $\sqrt{\frac{1}{5}}$, &c., and their intervals to be in the same progression. Hence the fringes and their intervals together were as the numbers 1, $\sqrt{\frac{1}{2}}$, $\sqrt{\frac{1}{3}}$, $\sqrt{\frac{1}{4}}$, &c.

When the hair was surrounded with water, the very same phenomena were seen, and metals, stones, glass, wood, horn, ice, &c., produced the very same fringes. The following was the order of the colours, reckoning from the shadow:—*First fringe*, violet, indigo, pale blue, green, yellow, red; *second fringe*, blue, yellow, red; *third fringe*, pale blue, pale yellow, red.

Fringes in homogeneous light.

When homogeneous light was used, Sir Isaac found that the fringes were *largest* in *red* light, *least* in *violet* light, and of an intermediate size in *green* light. In one case the distance between the middle of the first fringe on each side of the shadow was $\frac{1}{37{\cdot}5}$ of an inch in *red* light, and $\frac{1}{46}$ in *violet* light.

Periodical Colours.

Knife edges.

From experiments made by Sir Isaac Newton on the light which passed by the edge of a knife, and on that which passed between two knife-edges parallel to each other, he concluded that the light of the *first* fringe passed by the edge of the knife at a distance greater than the 100th part of an inch; the light of the *second* at a greater distance than that of the first; and the light of the *third* fringe at a greater distance than that of the second.

Sir Isaac then stuck into a board the points of two knives with straight edges, so that their edges formed an angle of 1° 47′ 26″, and from the observations which he made on the light which passed between them, he concluded *that the light which forms the fringes is not the same light at all distances of the paper from the knives*, obviously considering each fringe as produced like caustic curves, by the intersection of the inflected rays. When the fringes formed by these inclined knife-edges were received on paper held at a great distance, the fringes formed by the one knife-edge were bent into the shadow of the other knife, and formed cubical hyperbolas, whose asymptotes were for one set the knife-edge which produced the fringes, and a line perpendicular to the line bisecting the angle formed by the knives.

Dr Thomas Young.

Although many attempts were made during the last century to complete the unfinished labours of Newton on this subject, yet no decided discovery was made till the time of Dr Thomas Young. This distinguished natural philosopher, in endeavouring to explain the origin of the fringes which surrounded the shadow of the margin of a small circular aperture, conceived that the light nearest its centre was least inflected, and that nearest its edges most; and that another portion of light reflected from the margin of the aperture, and coinciding either exactly or nearly with the direct light, after a circuitous path, would interfere with that light, and produce colour. In November 1803 he confirmed this supposition to a certain extent, in so far as the production of the colours by interference was concerned, by his discovery of the interference of light, as already described.

The fringes formed by inflection, as observed by Dr Young, are shown in fig. 109, where ABCD is the shadow

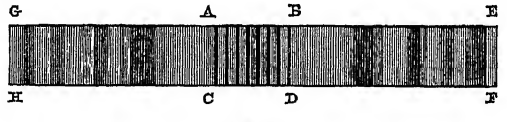

Fig. 109.

of the inflecting body with its *internal fringes*, which he considered as produced by the light passing on each side of the inflecting body, and bent into the shadow, so as to interfere in the manner already described. This is clearly proved to be the case; but he was less successful in explaining the external fringes between AC and GH, and between BD and EF. He ascribed them to the interference of rays *reflected from the margin* of the inflecting body, with rays which passed by it directly.

Dr Young examined the *crested fringes* of Grimaldi in the same manner as he did the internal fringes ABCD. He found that, when a screen was placed within a few inches of the inflecting angle of the body, so as to receive only one of the edges of the shadow, all the crested fringes disappeared; but if the rectangular point of the screen was opposed to the point of the shadow, so as barely to receive the angle of the shadow, or its extremity, the fringes were in no way affected.

M. Fresnel.

M. Fresnel in France, and M. Fraunhofer at Munich, were simultaneously engaged in studying the inflection of light, and each of them published the results of their labours, without any knowledge apparently that the other had been similarly occupied. We shall begin by giving an account of Fresnel's experiments.

Periodical Colours.

In place of a small hole, M. Fresnel substituted a lens of short focal length, which collected the solar rays into its focus, from which they again diverged. When bodies were placed in this bright light they gave distinct fringes, which he was able to measure at various distances behind the inflecting body, and at various distances of the inflecting body from the lens, simply by viewing the fringes with an eye-glass furnished with a micrometer. In this manner he measured their breadths within the one or two-hundredth part of a millimetre. He traced the external fringes up to their very origin, and by the aid of a lens of a short focus he saw the *third* fringe at the distance of less than the one-hundredth part of a millimetre from the edge of the inflecting body. He also found that the phenomena varied with the distance of the inflecting body from the luminous point, as in the following measures:—

Distance of the inflecting body from the focus of the lens.	Distance behind the body where the inflection was measured.	Angular inflection of the red rays of the first fringe.
4 inches	3·281 feet	12′ 6″
19·48 feet	3·281 „	3 55

When the inflecting body was kept at a fixed distance from the lens, M. Fresnel measured the inflection of the same fringe at different distances behind the inflecting body, and the result was, *that the successive positions of the same fringe did not lie in a straight line, but formed a curve, whose concavity is turned towards the inflecting body.* The successive positions of the same fringe in all the orders of colours he found to be hyperbolas, having the radiant point and the edge of the inflecting body for their common foci.

Contrary to the opinion of Dr Young, M. Fresnel found that the fringes were independent of the curvature of the margin of the inflecting body, and that when the margin was made extremely sharp, the small quantity of light which it could reflect would be incapable of producing, by its interference with the direct light, such bright fringes as are actually observed. To assure himself of this, he took two plates of steel, the edge of each of which was rounded in one-half of its length, and sharp in the remaining half; he placed the rounded portion of one edge opposite the sharp portion of the other, and *vice versa*. Hence, if the position of the fringes depended on the form of the surface, the effect would thus be doubled, and the fringes appear broken in the middle. They were, on the contrary, perfectly straight throughout their whole length.[1] M. Fresnel was therefore obliged to suppose that rays that pass at a sensible distance deviate from their primitive direction, and interfere with those which pass directly by the edge of the body.

In order to settle this question, M. Fresnel compared the results of Dr Young's hypothesis with those of his own, and he found that the breadth of any fringe of homogeneous light should be on the two hypotheses as 2 to 1·8726, and having measured the diameter of such a fringe, he found his own hypothesis more correct than Dr Young's.

In order to exhibit to the eye the hyperbolic form of the fringes, we have given a representation of them in fig. 110, where LL′ is a lens of short focus, by which the rays of the sun entering a dark chamber are refracted to a focus F, from which they again diverge, forming the cone F*mn*; or the lens may be fixed in a large diaphragm DD′, which may stand on the table before the window at which the sun's light enters. By means of a coloured glass VV′ placed on either side of the diaphragm, or on either side of F, the light may be rendered homogeneous. If we now place a screen of any kind EC at some distance from F, having its edge somewhat smaller, and free of dust, and receive its shadow GT′ upon a sheet of paper, or any white ground TT′, or on a glass plate roughened with emery, we shall obtain the section of the fringes formed by

[1] *Mémoire sur la Diffraction* p. 370; Prof. Lloyd's *Report, ut antea.*

Periodical Colours.

diffraction. The line FEG, which is the geometrical shadow, is not the real shadow. On the side of it towards GT', the paper will not appear *black*, but illuminated with a visible shade, which goes on decreasing nearly uniformly for a considerable distance. On the other side of EG there are several fringes or alternations of light and darkness. The *first* fringe B parallel to the shadow is *bright*, then a band S almost entirely black, which is the *black fringe* of the *first order*, then a second *bright* fringe B', which is followed by the *second black fringe* S'. These alternations continue to a great distance from G, so that even the sixteenth or seventeenth order may be observed, the bright fringes becoming less coloured, and the black ones more luminous, till they are no longer visible.

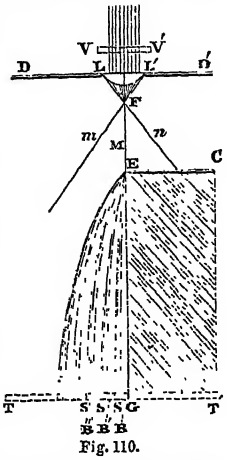

Fig. 110.

By varying the distance of the paper TT' from the screen EC, or of the screen from the focus F, the same fringes are produced with certain variations depending on their distances, the fringes being propagated in hyperbolas, as shown in the figure. The fringes are *largest* in *red* light RR, smallest in *violet* light VV, and of an intermediate size in *green* light GG, as represented in fig. 111, where they are shown as on each side of the shadow of a human hair HH.

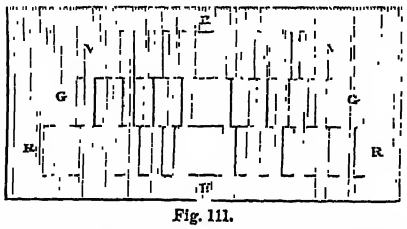

Fig. 111.

The following table shows the angular distances of the seven first fringes from the inflecting body EC (fig. 110), and the geometrical shadow:—

For Red Light.

	Angles, FE=1000 millimetres.	Angles, FE=100 millimetres.	Angles, FE=10 millimetres.
First order	3′ 35″	11′ 20″	0° 35′ 51″
Second order	5 15	16 35	0 52 25
Third order	6 30	20 32	1 4 56
Fourth order	7 32	23 50	1 15 21
Fifth order	8 27	26 44	1 24 31
Sixth order	9 17	29 20	1 32 44
Seventh order	10 3	31 45	1 41 21

For Violet Light.

First order	2′ 58″	9′ 22″	0° 29′ 36″
Second order	4 20	13 42	0 43 18
Third order	5 21	16 55	0 53 36
Fourth order	6 13	19 40	1 2 15
Fifth order	6 59	22 5	1 9 48
Sixth order	7 40	24 15	1 16 38
Seventh order	8 18	26 14′	1 22 53

Sir John Herschel.

When the diverging light passes through a small circular aperture, very beautiful phenomena are observed, which were studied about the same time by M. Fresnel and Sir John Herschel.[1] M. Fresnel had deduced the phenomena from theory, and subsequently confirmed his deductions by experiment. The following is Sir John Herschel's[2] account of the phenomena:—"Suppose," says he, "we place a sheet of lead, having a small pin-hole pierced through it, in the diverging cone of rays from the image of the sun formed by a lens of short focus, and in the line joining the centres of the hole and focus prolonged, place a convex lens or eye-glass, behind which the eye is applied. The image of the hole will be seen through the lens as a brilliant spot, encircled by rings of colours of great vividness, which contract and dilate, and undergo a singular and beautiful alternation of tints, as the distance of the hole from the luminous point on the one hand, or from the eye-glass on the other, is changed. When the latter distance is considerable, the central point is white, and the rings follow nearly the order of the colours of thin plates. Thus, when the diameter of the hole was about 1-30th of an inch, its distance (a) from the luminous point about six feet six inches, and its distance (b) from the eye-lens twenty-four inches, the series of colours was observed to be,

Periodical Colours.

"1*st Order*, White, pale yellow, yellow, orange, dull red.

"2*d Order*, Violet, blue (broad and pure), whitish, greenish-yellow, fine yellow, orange-red, very full and brilliant.

"3*d Order*, Purple, indigo-blue, greenish-blue, pure brilliant green, yellow-green, red.

"4*th Order*, Good green, but rather sombre and bluish, bluish-white, red.

"5*th Order*, Dull green, faint bluish-white, faint red.

"6*th Order*, Very faint green, very faint red.

"7*th Order*, A trace of green and red.

"When the eye-lens and hole are brought nearer together, the central white spot contracts into a point and vanishes, and the rings gradually close in upon it in succession, so that the centre assumes in succession the most surprisingly vivid and intense hues. Meanwhile the rings surrounding it undergo great and abrupt changes in their tints. The following were the tints observed in an experiment made some years ago, the distance between the eye-glass and luminous point ($a+b$) remaining constant, and the hole being gradually brought nearer to the former:—

b =	Colour of the Central Spot.	Surrounded by
24·00	White	Rings as in the foregoing description.
18·00	White	The two first rings confused, the red of the 3d, and green of the 4th orders splendid.
13·50	Yellow	Interior rings much diluted, the 4th and 5th greens, and 3d, 4th, and 5th reds, the purest colours.
10·00	Very intense orange	All the rings are now much diluted.
9·25	Deep orange-red	The rings all very dilute.
9·10	Brilliant blood-red	The rings all very dilute.
8·75	Deep crimson-red	The rings all very dilute.
8·36	Deep purple	The rings all very dilute.
8·00	Very sombre violet	A broad yellow ring.
7·75	Intense indigo-blue	A pale yellow ring.
7·00	Pure deep blue	A rich yellow.
6·63	Sky-blue	A ring of orange, from which it is separated by a narrow sombre space.
6·00	Bluish-white	Orange-red, then a broad space of pale yellow, after which the other rings are scarcely visible.
5·85	Very pale blue	A crimson-red ring.
5·50	Greenish-white	Purple, beyond which yellow, verging to orange.
5·00	Yellow	Blue, orange.
4·75	Orange-yellow	Bright blue, orange-red, pale yellow, white.
4·50	Scarlet	Pale yellow, violet, pale yellow, white.
4·00	Red	White, indigo, dull orange, white.
3·85	Blue	White, yellow, blue, dull red.
3·50	Dark blue	Orange, light blue, violet, dull orange.

[1] Sir John Herschel's experiment was made on the 12th July 1819, but was not published till 1825. [2] *Treat. on Light*, sect. 729, 730.

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"The series of tints exhibited by the central spot is evidently, so far as it goes, that of the reflected rings in the colours of thin plates; the surrounding colours are very capricious, and appear subject to no law."

We owe also to Sir John Herschel the following beautiful experiment with two equal apertures placed near each other. The rings are formed about each as in the case of one aperture, but these are accompanied with a set of straight parallel fringes, bisecting the interval between their centres, and perpendicular to the line joining their centres. Two other sets of similar fringes appear in the form of a St Andrew's cross, forming equal angles with the first set, as shown in fig. 112. When the apertures are unequal, as in fig. 113, these

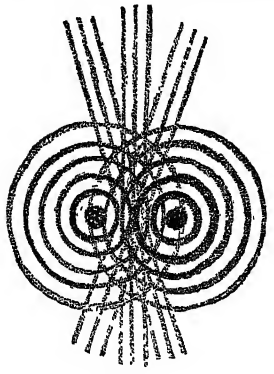

Fig. 112.

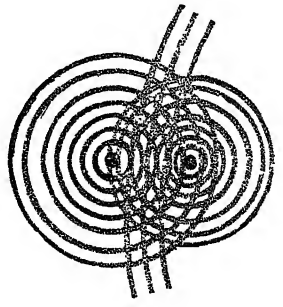

Fig. 113.

fringes assume the form of hyperbolas, having the apertures in their common focus. By varying the number and shape of the apertures, the phenomena became exceedingly beautiful.

M. Poisson.

M. Poisson deduced from theory that the centre of the shadow of a small circular opaque disc, exposed to light emanating from a single luminous point, would be precisely as much illuminated by the diffracted light as it would be by the direct light if the disc were removed. By using a small disc of metal, cemented to a clear and homogeneous plate of glass, M. Arago confirmed this very remarkable result.

M. Arago.

We owe to M. Arago a series of beautiful discoveries respecting the influence of transparent screens in the phenomena of inflection. When a thick piece of glass is used as a screen on one side of the inflecting body, the rings wholly disappear, as if the screen were opaque. If the screen is very thin, like a film of sulphate of lime or mica, the fringes still remain visible, but shift their places, and are moved from the side where the screen is interposed.

If we make this experiment on the fringes produced by two apertures, we have only to cover one of the apertures with the screen. The same effect, however, will be produced if we cover both apertures with screens of different thicknesses. In this case the fringes will shift their places from the thicker plate, without suffering any other change.

This beautiful property has been most ingeniously employed by MM. Arago and Fresnel in measuring the refractive powers of different gases. For as the displacement of the coloured fringes depends on the refractive power as well as thickness of the plate, its refractive power may be computed from the displacement. In the same manner, if one of the interfering rays is made to pass through tubes filled with different gases, while the other does not, the displacement produced by the gas will give a measure of the refractive power of the gaseous medium.

Negative diffraction.

In all the preceding phenomena of diffraction the fringes or the foci of the interfering pencils are seen, in the anterior focus of the lens by which they are viewed and magnified, as produced at different distances *behind* the diffracting body *b* or B (fig. 114). These classes of fringes may be called *positive*, because they are formed in space, or upon a screen, by rays crossing in a focus, as it were, at different distances behind the diffracting body; but I have examined another class of fringes which may be called *negative*, because they are not brought to a positive focus in space, or do not interfere till they reach the retina. In order to see these fringes, place the lens behind the diffracting body B, so as to see it distinctly, and without fringes. If we now advance the lens towards B, we shall see fringes formed

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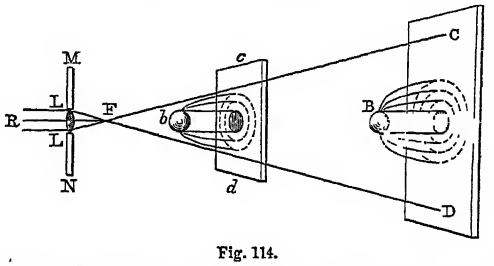

Fig. 114.

round B, and of the same size as if we had withdrawn it as much behind its first position. The fringe increases as we advance the lens, and when it touches B, the fringes are the same nearly as if it had been twice its focal length behind B. If we wish to see the fringes larger, we must use a lens with a longer focus; and when the lens touches the diffracting body, the fringes will be the same as if they were seen by the lens when placed at twice its focal length behind B. In all these cases the interfering rays which produce the fringes are those which virtually radiate from the anterior focus of the lens, and which, being refracted into parallel directions, enter the eye, where they interfere on the retina. The negative fringes will also be seen if the lens is placed anywhere between the diffracting body and the focus F of diverging rays in fig. 114.

In consequence of the rays which produce the fringes not crossing one another before they enter the eye, the *negative* fringes are much more distinct than the *positive* ones, a fact already established by the superior distinctness of vision in the Galilean telescopes where the rays do not form a positive image before they enter the eye, and in the Cassegrainian telescope before they fall upon the eye-piece.

The phenomena of diffraction are beautifully seen by using a *transparent* diffracting body, such as lines drawn upon glass by fluids either pure or holding gums or other transparent bodies in solution. The colours are so splendid that an instrument could thus be constructed for giving new rectilineal patterns of ribbons of all forms and colours.[1]

Fraunhofer.

The following experiments of Joseph Fraunhofer, made with instruments of extreme accuracy, furnish data of the highest importance in physical optics.[2]

The apparatus employed by Fraunhofer was a repeating theodolite whose vernier read off to 4″. In the centre of the circle, but above it, this instrument carries a flat circular plate 6 inches in diameter, having its axis coincident with that of the theodolite, and graduated separately to 10″. In the middle of this disc is placed a metallic screen, in which the necessary apertures are made, and which is in the axis of the theodolite. The divisions of this disc serve to measure, if necessary, the angle of incidence of the rays. A telescope, having an object-glass of twenty lines in aperture, and 16·9 inches in focal length, is placed 3½ inches from the centre of this disc. This telescope is placed firmly on the alidade of the divided circle, whose diameter is 12 inches, and the whole is counterpoised. The axis of the telescope is exactly parallel to the horizon, as well as to the plane of this circle. The magnifying power which he employed was from thirty to fifty times. The instrument

[1] Brewster's *Optics*, pp. 116, 117.

[2] *Neue Modifikation des Lichtes durch gegenseitige Einwirkung und Beugung der Strahlen, und Gesetze derselben*, von Jos. Fraunhofer in Munchen. Without a date.

Periodical Colours.

did not communicate with the floor of the room, from which it was wholly insulated. The heliostate was placed in the prolongation of the optical axis, at a distance of 38 feet 7½ inches from the centre of the theodolite. In order to make the heliostate follow the sun in his hourly motion, the observer could move the screw of the mirror by means of a long rod of iron, which extends from the heliostate to the theodolite, and with this apparatus he could also vary at pleasure the intensity of the solar light. The opening of the heliostate is vertical, being 2 inches high, and commonly from the 50th to the 100th of an inch.

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By means of an achromatic microscope, magnifying 110 times, Fraunhofer measured the aperture in the metallic screen, which he did to the fifty-thousandth, and sometimes to the hundred-thousandth part of an inch, provided the body was very fine at its edge.

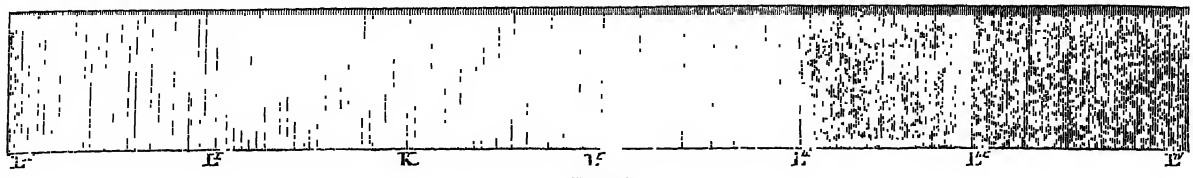

Fig. 115.

Fraunhofer's first observations were made with a single slit, which was placed before the object-glass of the telescope, which had been previously directed to the aperture in the heliostate, so that the aperture was bisected by the wire of the micrometer. He then saw the fringes shown in fig. 115. The middle fringe or band $L^I L^I$, bisected by the micrometrical wire K, was *white*, becoming yellow towards L^I and L^I, where it was red. In the space L^I L^{II} there is a spectrum with very lively colours,—viz., *indigo* near L^I, then *blue*, *green*, *yellow*, and *red*, near L^{II}. The spectrum in L^{II} L^{III} is much less intense,—viz., *blue* near L^{II}, and *yellow*. *green*, and *red* near L^{III}. The spectrum in the space L^{III} L^{IV} is still fainter, being *green* on the side L^{III}, and *red* on the side L^{IV}. A great number of spectra follow these, becoming fainter and fainter, and losing themselves in a band of light, which is spread over a great space. All these spectra on both sides of K are perfectly equal, and consequently symmetrical. Both the colours and the spectra shade into one another imperceptibly. The following table contains the average of the distances L^I, L^{II}, L^{III}, and L^{IV}, from the central line, all of them being equal, the measures being taken from the red extremity of each spectrum; so that if we wish to have the angle of deviation of L^{II} from K, we have only to multiply the value of L in the table by 2; and so on.

Width of the aperture in parts of a Paris inch.	Breadth of each spectrum, or values of KL^I, KL^{II}, &c.	Product of the aperture by the deviation L.
0·11545	0′ 37″·66	0·0000210
0·06098	1 11·17	0·0000210
0·03690	1 56·6	0·0000209
0·02346	3 4·43	0·0000210
0·01237	5 48·7	0·0000209
0·01210	6 1·84	0·0000212
0·01020	6 57·3	0·0000206
0·00671	11 6·4	0·0000217
0·00642	11 12·2	0·0000209
0·00337	21 10·3	0·0000207
0·00308	23 32·7	0·0000211
0·00218	3 40	0·0000213
0·00215	35 17	0·0000220
0·00114	1° 4 53	0·0000215

From these observations M. Fraunhofer deduces the following conclusions:—

1. *That the angles of deviation of the luminous rays which pass through a single aperture are in the inverse ratio of the width of that aperture.*

2. *That when a ray is diffracted in passing through a narrow aperture, the distance of similar rays from the middle in the several spectra, form in each case an arithmetical progression, whose difference is equal to the first term.*

3. *That if* γ *is the aperture, the arches* L^I, L^{II}, *or the deviation of the inflected rays, are in general for the radius of a circle equal to* 1, $L^I = \frac{0{\cdot}0000211}{\gamma}$, $L^{II} = 2 \cdot \frac{0{\cdot}0000211}{\gamma}$, $L^{III} = 3 \cdot \frac{0{\cdot}0000211}{\gamma}$.

By observing whether the micrometer wire appeared or disappeared in the different spectra, Fraunhofer ascertained that the spectra nearest K are not composed of homogeneous light, but that the light becomes more and more homogeneous at greater distances from the axis.

Fraunhofer next proceeds to describe the phenomena observed when the two edges which form the narrow aperture *are at different distances* from the object-glass. When the effective width of the aperture thus formed is from the 25th to the 50th of an inch, the spectra are the same as those before described; but when the opening becomes less, the spectra on one side of the axis become wider horizontally than those on the other side. When the apparent aperture is extremely narrow, the spectra on one side are two or three times wider than those on the other. By continuing to close the distant edges, the longest spectra begin to disappear successively, so that the fifth spectrum, for example, fills almost suddenly the whole field of the telescope till it ceases to be visible, then the fourth spectrum presents the same phenomena, then the third; and so on. During these changes the spectra on the other side remain unchanged; but when all the former have vanished, *they also disappear in their turn, not successively, but all at once*, which happens when no light passes between the edges. The large spectra are always on the side of the screen which is nearest the object-glass.

When the apertures, both in the heliostate and in front of the object-glass, are small circular ones, a system of rings is produced absolutely the same as those of thin plates, with this difference only, that the centre is *white* in place of *black*. The rings increase in size as the apertures diminish. By varying the apertures Fraunhofer obtained the following results:—

1. *That the diameters of the coloured rings are in the inverse ratio of the diameters of the apertures.*

2. *That the distances of the extreme rings (of any given refrangibility) from the centre, form an arithmetical progression, whose difference is smaller than the first term.*

3. *That if* γ *is the diameter of the aperture in Paris inches, we shall have*

$$L = \frac{0{\cdot}0000214}{\gamma} = L^{II} - L^I = L^{III} - L^{II}, \text{ \&c.}$$

$$L^I = \frac{0{\cdot}0000257}{\gamma}$$

$$L^{II} = \frac{0{\cdot}0000257}{\gamma} + L; \text{ and so on.}$$

Spectra produced by gratings and grooves.

The most important and interesting of Fraunhofer's researches are those which relate to the spectra produced by gratings, consisting of a number of parallel wires placed parallel also to the narrow linear aperture in the heliostate. He formed these gratings of fine wires stretched across a rectangular frame; the two shorter ends of the frame consisted of two fine screws made with the same die, and

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having 260 threads in an inch. By placing a wire in each thread he insured their exact parallelism. The diameter of each wire was 0·0Q2021 of a French inch, and the edge of each wire was distant from the adjacent edge 0·003862 of an inch. The aperture of the heliostate was 2 inches long, and the 100th of an inch wide, and the frame of wires was placed before the object-glass, so that no other light could be admitted but through them. Fraunhofer was astonished at the phenomena which he saw. He saw the colourless line of light A (fig. 116), in the aperture of the heliostate,

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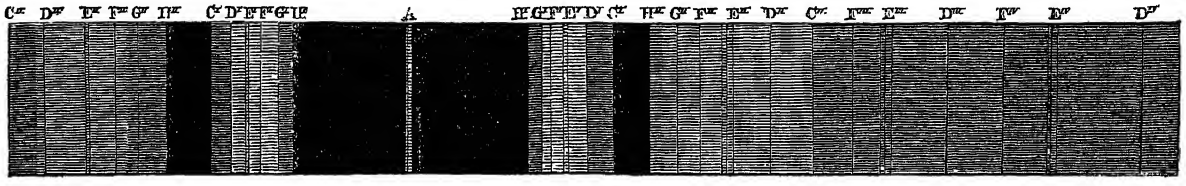

Fig. 116.

exactly as if no wires had been interposed, and at some distance from it on both sides *a great number of coloured spectra exactly similar to those produced by a good prism.* They were larger in proportion to their distance from the central bright line, and they diminished in intensity in the same proportion. A part of these spectra are shown in fig. 116, where A is the aperture of the heliostate, absolutely without colours. On each side of A the spectra are perfectly symmetrical. When the apparatus is well made, the space AH^{I} is absolutely black. The *first* spectrum occupies the space $H^{I}C^{I}$; H^{I} being the usual limit of the violet, and C^{I} that of the red. Between H^{II} and C^{II} there is a second spectrum twice as long as the first, the order of the colours being the same, but their intensity a little less. The third spectrum occupies the space between C^{II} and F^{IV}, but a part of its violet rays are mixed with the red of the *second* spectrum, and also a part of the *red* rays of the *third* with the *blue* rays of the *fourth* spectrum. The *fourth* spectrum is seen between F^{IV} and D^{IV}, its *blue* extremity losing itself in the *third*, and its *red* extremity in the *fifth* spectrum. Many other spectra succeed these, and when the apparatus is good, *thirteen* may be easily reckoned on each side of A.

But what is the most interesting fact, when the apparatus is good, and the adjustments correct,—the *fixed dark lines in the prismatic spectrum* are seen at C^{I}, D^{I}, these lines being the same as those similarly marked in fig. 87. It is remarkable, however, that A is not seen, a fact which M. Fraunhofer neither notices nor explains. The lines, both great and small, are absolutely the same, both in this and the prismatic spectrum, though their distances are widely different.

Diffracted and water spectra compared.

In a grating in which γ, the distance between the wires, is 0·000628, and δ, or the diameter of the wires, 0·001324, the following are the distances:—

		Diffracted Spectrum.	Water Spectrum.
Distance between the lines B^{I} and C^{I}	...	2′ 2″·6	1′ 3″·3
" " " C^{I} " D^{I}	...	4 23·2	2 41
" " " D^{I} " E^{I}	...	4 5·2	3 16
" " " E^{I} " F^{I}	...	2 39·9	2 47
" " " F^{I} " G^{I}	...	3 37·6	5 57
" " " G^{I} " H^{I}	...	2 12·5	4 14
Total length from B^{I} to H^{I}	...	19 1·0	19 1·3

The diffracted spectrum is therefore a very extraordinary one. The *green* space from E to F is almost exactly the same in both, but all the less refrangible spaces are greatly expanded in the diffracted spectrum, and the more refrangible spaces greatly contracted, the *red* space CD in the diffracted spectrum being *twice as great* as in the water spectrum; and the *violet* space in the water spectrum twice as small.

M. Fraunhofer repeated the above experiments with *ten* different gratings, in which the breadth of the wires and the spaces between them were varied, and he deduces from them the following laws:—

1. *For two different gratings in which the parallel wires are of the same size and placed at equal distances, the magnitude of the spectra which arise from the reciprocal influence of a great number of rays diffracted by narrow apertures, and their distances from the axis, are in the inverse ratio of the intervals $\gamma+\delta$; that is, the space from the middle of one of the openings to the middle of the other.*

2. *In all the perfect mean spectra, or those in which the fixed lines are seen, the distances between the coloured rays of the same nature in the different spectra, or between the same fixed lines in them, form an arithmetical progression, whose distance is equal to the first term.*

3. *In gratings in which the diameter δ of the wires, and the distance γ between them, is expressed in Paris inches, the first term of the progression for the fixed lines* B, C, D, E, *or those rays which have the corresponding degrees of refrangibility, is represented by the following numbers:—*

$$B=\frac{0\cdot00002541}{\gamma+\delta};\quad C=\frac{0\cdot00002425}{\gamma+\delta};\quad D=\frac{0\cdot00002175}{\gamma+\delta};$$

$$F=\frac{0\cdot00001943}{\gamma+\delta};\quad F=\frac{0\cdot00001789}{\gamma+\delta};\quad G=\frac{0\cdot00001585}{\gamma+\delta};$$

$$H=\frac{0\cdot00001451}{\gamma=\delta}.$$

If we represent the numerator of each of these expressions by a, the angle of deviation of one of the same coloured rays in the *first* spectrum by θ', in the *second* by θ'', in the *third* by θ''', we have generally

$$\theta'=\frac{a'}{\gamma+\delta'},\quad \theta''=\frac{a''}{\gamma+\delta'},\ \&c.$$

If ν stands for the number of the spectrum, ν being $=0$ for the axis, $=1$ for the first spectrum, 2 for the second spectrum, and if we put $\epsilon=\gamma+\delta$, we shall have in general,

$$\theta^{(\nu)}=\frac{\nu a}{\epsilon}.$$

The preceding results having been obtained with angles so small that the arcs and their sines and tangents are nearly in the same proportion, M. Fraunhofer began a new series of experiments, with the view of obtaining spectra in which the angles should be larger, and by which he might determine whether it was the arcs or their sines or tangents which had the proportions assigned by the experiments.

This inquiry rendered it necessary to obtain much finer gratings than those he had used. He therefore coated a plate of glass with two or three folds of gold-leaf, in order to have the interstices filled up, and by a peculiar arrangement he traced upon the glass parallel lines in which ϵ was $=0\cdot00114$ of an inch. When the lines were drawn closer, no gold remained upon the glass. With this system the spectra were larger, and the fixed lines distinctly seen, but they did not answer his purpose. He therefore thought of spun glass, which answered as well as wires; and having covered a plate of glass with a thin coat of fat, so thin that it could scarcely be seen, he traced parallel lines upon it, the intervals of which were only half the size of those on the gold-leaf. The spectra produced by this system of lines gave the fixed lines very distinctly, so that their distances

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from the axis could be accurately measured; but he could not succeed in tracing, either upon a layer of fat or black varnish, lines closer than this. He at last succeeded in his object of tracing a finer system of lines by using a diamond, with which, by the aid of a machine, he traced lines so fine upon the surface of glass that they could not be seen by the most powerful compound microscope. In this way he obtained a set of several thousand lines, in which $\epsilon = 0{\cdot}0001223$ of an inch, and which were at distances so very equal that the fixed lines in the first and second spectrum were clearly seen.[1]

With the system when $\epsilon = 0{\cdot}0001223$, and the number of lines 3601, the fixed line D is seen double in the first spectrum.

When the light fell vertically on this grating, Fraunhofer obtained the following measures:—

Names of fixed lines.	Distance of fixed lines from the axis A. Fig. 8, Plate 1.	Distance of lines in first spectrum.
C^I	11° 25′ 20″	C^I from D^I
C^{II}	23 19 42	1° 10′ 49″
D^V	10 14 31	D^I from E^I
D^{II}	20 49 44	1° 5′ 31″
E^I	9 9 0	E^I from F^I
E^{II}	18 32 34	0° 32′ 54″
F^I	8 26 6	F^I from G^I
$F^{\cdot}$	17 3 34	0° 58′ 47″
$G_{\cdot}$	7 27 19	G^I from H^I
G^{II}	15 3 9	0° 34′ 43″
H^I	6 52 36	

With this grating, the *third*, *fourth*, and following spectra were well seen, but the fixed lines could not be seen with sufficient distinctness for accurate measurement in those beyond the *first* and *second*.

He therefore used another grating in which $\epsilon = 0{\cdot}005919$ of an inch; and when the light fell upon it vertically, he obtained the following results for the first five spectra with the lines D, E, and F, for the first four with E, for the first three with F and G, and for the first two with H.

Names of fixed lines.	Distance of fixed lines from axis.	Names of fixed lines.	Distance of fixed lines from axis.
C^I	2° 20′ 57″	E^V	9° 28′ 3″
D^I	2 6 30	F^I	1 44 19
D^{II}	4 13 7	F^{II}	3 28 45
D^{III}	6 20 7	F^{III}	5 13 23
D^{IV}	8 27 43	F^{IV}	6 58 18
D^V	10 35 53	G^I	1 32 22
E^I	1 53 7	G^{II}	3 4 57
E^{II}	3 46 17	G^{III}	4 37 30
E^{III}	5 39 50	H^I	1 27 0
E^{IV}	7 33 41	H^{II}	2 50 11

All the observations made with both the systems of lines are represented by the expression

$$\sin \theta^{(\nu)} = \frac{\nu a}{\epsilon}.$$

That is, with rays falling vertically, the sines of the angle of deviation of any fixed line or ray of definite refrangibility from the axis in the different spectra which succeed others, are as the numbers 1, 2, 3, 4, 5.

The last of these systems of lines has the remarkable property of having all the spectra on one side of the axis twice as luminous as those on the other. Fraunhofer supposed that one of the sides of each line had been sharper than the other, and confirmed this opinion by tracing lines on a layer of fat, so that one line was less sharp than the other, and it produced the same inequality in the intensity of the light of the spectra on each side of the axis.

If the ray does not fall vertically upon the system of grooves or lines, but is inclined to it in a plane which intersects the parallel lines vertically, the same effect is produced as if the distance between the middle of the lines, or ϵ, were diminished in the ratio of the radius to the cosine of the angle of incidence. Hence *the distance of the spectra from the axis increases as the cosine of the angle of incidence.* If σ therefore is the angle of incidence, then we have—

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$$\sin \theta^{(\nu)} = \frac{\nu a}{\epsilon \cos \sigma}.$$

This, however, is only true when the system of lines is coarse and σ not very large. But in fine systems of lines it is otherwise—the spectra on both sides of the axis are no longer symmetrical; and in the system where $\epsilon = 0{\cdot}0001223$, when σ is $= 55°$, we have the deviation of D′ on one side of the axis $= 15°\ 16'$, and on the other side of the same axis $30°\ 33'$.

Spectra by reflection.

Hitherto we have treated of spectra formed by the light transmitted through the gratings, or through plates of glass with systems of lines etched upon one of its surfaces. But M. Fraunhofer examined also the spectra produced by *reflection* from the etched surfaces of the glass plates. For this purpose, he coated the surface of the glass with a black resinous varnish of the same refractive power as the glass. Then when light reflected from the system of lines fell on the object-glass of the telescope, the very same phenomena appeared as when the light passed through the same system of lines at the same angle of inclination, spectra not symmetrical being seen. The intensity of the spectra was still such that the distances of the various lines can be determined with great accuracy.

Polarization of some of the diffracted light.

M. Fraunhofer has noticed it as very remarkable that, under a certain angle of incidence, a *portion of a spectrum* produced by reflection consists of entirely polarized light. This angle of incidence varies greatly for the different spectra, and even still very perceptibly for the different colours of one and the same spectrum. Thus, with the glass system of lines, where $\epsilon = 0{\cdot}0001223$, the ray E^I in the green part of the first spectrum is polarized when $\sigma = 49°$, but the same green part of the *second* spectrum on the same side of the axis is only polarized when $\sigma = 40°$, and the green part of the first spectrum lying on the opposite side of the axis is not polarized till $\sigma = 69°$. In this last case the remaining colours of the spectrum are imperfectly polarized. This was less the case in the second spectrum above mentioned, where the colour still remained polarized when the angle of incidence was perceptibly altered. In the spectrum where the green light was polarized at 69°, the light was at no angle of incidence so completely polarized as in the first spectrum at 49°. With a system of lines in which ϵ is larger than the one above mentioned, the green rays in the spectra already referred to are polarized at totally different angles of incidence.

A very singular consequence arises from the formula deduced from theory by M. Fraunhofer, and representing his experiments. If the distance ϵ between the lines is less than the length of an undulation, and the light falls vertically on the grating, so that $\sigma = 0$, it follows that *no coloured ray remains visible*, however the light may fall, and only the *white* light becomes visible in the axis. Hence all scratches or inequalities on polished surfaces can produce no spectra, or no disturbance in the light which the surface refracts or reflects, and consequently no imperfection in the images which they form. M. Fraunhofer likewise draws the conclusion "that it would be impossible by

[1] M. Fraunhofer remarks that it requires much good fortune, even with $\epsilon = 0{\cdot}0001223$, to find a diamond point which shall trace *several thousands* of such lines without being altered, and he had succeeded only in obtaining one system. It is only by trial that a useful diamond point can be obtained. As every line requires to be drawn singly with great care, the labour of drawing two thousand is enormous. Fraunhofer drew lines so close that there were 32,000 of them in a Paris inch. By etching the first and last lines of the system somewhat stronger than the rest, he measured, by a microscopic apparatus, the distance between these two lines, the etching machine itself reading the lines which were etched. In this way, knowing the number of lines, viz., 3601, and the distance between the first and last, he obtained ϵ, or the distance between the middle of any two lines.

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any means to render such inequalities (those less than ϵ) visible," and that a microscopic object, the diameter of which is $=\epsilon$, and consists of two parts, cannot be recognised as consisting of two parts. "This," he adds, "shows us the limits which are set to vision through microscopes." This result, if clearly established, would be a very remarkable one.

It is very obvious, that if the distances of the etched lines or the wires in gratings are unequal, the *larger* distances ϵ will give *smaller* spectra, and the *smaller* distances ϵ *larger* spectra, which will be mixed with each other. Fraunhofer, however, conceived it would be interesting to know what would happen if the intervals ϵ were *regularly unequal*, that is, if the inequality in the distances were regularly repeated in equal parts. With this view, he etched parallel lines in various ways, regularly unequal upon plates of glass covered with gold leaf. If the distances between the lines are expressed by ϵ', ϵ'', ϵ''' and if one of the equal parts which consists of unequal ϵ's is expressed by $\epsilon' + \epsilon'' + \epsilon''' \ldots\ldots + \epsilon^n$, then the distances of the various spectra were found by experiment to be

$$\sin \theta^{(\nu)} = \frac{\nu a}{\epsilon' + \epsilon'' + \epsilon''' \ldots\ldots + \epsilon^n}.$$

The phenomena of spectra thus produced are chiefly remarkable on account of their different intensity. With some systems of lines of this kind, *several spectra, or parts of them, may be wholly wanting*, or have so slight an intensity that they are not easily observed; whilst the succeeding ones, again, become very intense. Owing to this cause, the fixed lines in these spectra may be observed. In the usual systems consisting of equal spaces ϵ, the lines C^{XII}, F^{XII}, or the fixed lines C, F, in the twelfth spectrum can be seen; but with a regularly unequal system of lines, where every division consists of three shades ϵ different among themselves, and are as 25 : 33 : 42, the lines C^{XII}, D^{XII}, E^{XII}, and F^{XII} are seen with such distinctness that their distances from the axis can be accurately measured. The reason of this is, that with such systems of lines, the tenth and the eleventh spectra are almost wholly wanting. With this system of lines, indeed, Fraunhofer saw E^{XXIV}, or the line E in the 24th spectrum, so distinctly that its distance could be measured.

When the gratings and systems of lines are immersed in fluids, the same phenomena are produced, but the distances of all the spectra from the axis are diminished in the inverse ratio of the indices of refraction.

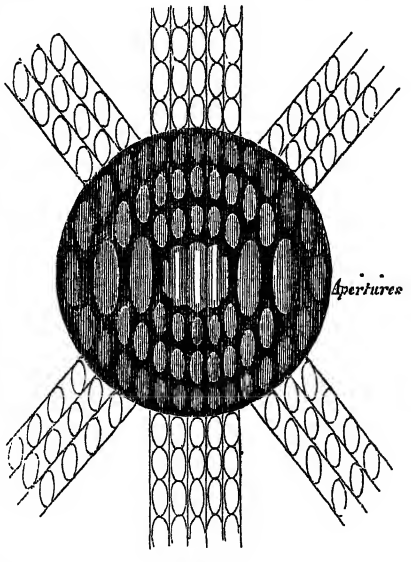

Fig. 117.

Fraunhofer has given also some fine drawings of a beautiful class of phenomena produced by the diffraction of light passing through round and quadrangular apertures, either singly or arranged regularly. When a plate of brass perforated with two equal apertures 0·02227 of an inch in diameter, and 0·03831 distant, is placed in front of the object-glass, and the aperture of the heliostate round, the extraordinary appearance shown in fig. 117 was seen. It consisted of 65 elliptical spectra distributed in concentric rings, the outermost of which contains 28 spectra, the next 20, the next 12, and the central one 5. When the circular apertures are arranged so as to correspond with the four angles of a square, the effect produced is similar to fig. 118.

Periodical Colours.

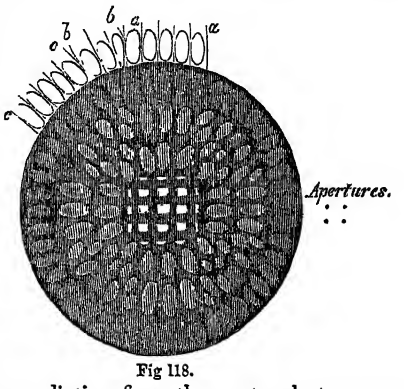

Fig 118.

One of the most splendid figures of this kind is produced by crossing two gratings with the wires at right angles to each other: a circular image is covered with narrow spectra radiating from the centre, but occupying only parts of different radii. The spectra are rectangular, of about a line wide, and from five lines to five inches long. The violet end of each is towards the centre. In some places the spectra touch and overlap each other, but the greater number are insulated.

Our limits will not permit us to pursue this curious subject any farther, and we must refer our readers to Fraunhofer's own work,[1] and to another published by Schwerd of Spires in 1835,[2] in which he has given drawings of an immense variety of beautiful phenomena.

As the various phenomena of diffraction observed by Arago, Fresnel, Young, Fraunhofer, and Schwerd are susceptible of being explained by the undulatory theory, even facts of the same class, and having a similar origin, cannot possess much interest in our inquiries into the physical causes to which they must be ultimately referred.

We shall now proceed, however, to give an account of a new series of facts discovered by Sir David Brewster.

Recent discoveries.

In all the phenomena of gratings and systems of lines observed by Fraunhofer, the central image of the luminous aperture in the heliostate is white, a result that might have been expected, as that light is reflected from the original surface of the glass, and cannot interfere with any other light. "If the lines," says Fraunhofer, "were so thick that one touched another, and consequently had no space between them, no light could be regularly reflected from the etched surface, and would, as from every other polished surface, be dispersed. Were the intermediate spaces equally wide as the lines, the etched surface could only regularly reflect half as much light as an equal surface of glass that was not etched; therefore the quantity of regularly reflected light from an etched surface of glass is in proportion to the quantity of light which is reflected from a surface of glass of the same size not etched, or as the width of the spaces between any two neighbouring lines is to the width of these lines."[3]

These conclusions, however irresistible they seem to be, are very far from being correct; for, upon examining a series of several systems of lines or grooves cut on steel for him by the late Sir John Barton, Sir David Brewster observed, that in several of them the central image hitherto described as *white* or colourless had a distinct colour, which was the same in every part of the system. In one of the systems, on which there were 1000 lines in an inch, the central image had its tint a *greenish-blue* at a perpendicular

[1] See *Edin. Journal of Science*, N.S., No. xiii., p. 101, and No. xiv., p. 251.

[2] *Die Beugungs-ersheinungen, aus dem Fundamental-gesetz dem undulations theorie analytische entwickelt und in Bieldern dargestellt*, von F. M. Schwerd, Manheim, 1835.

[3] Fraunhofer, *Edin. Jour. of Science*, No. xiii., p. 109.

Periodical Colours.

incidence, which suffered no change by turning round the plate, nor by reflecting the light from different parts of the system. He found the same colours on various other systems of lines, and upon examining them at different angles of incidence, he found that the tints varied with the incidence, being a maximum at a vertical incidence, diminishing as the incidence increased, and disappearing at an angle of 90°. The following were the general results with the grooves on steel:—

Number of grooves in the inch.	Orders and portions of orders of colours from 0° to 90° of incidence.
500	Citron-yellow of the first order shading to white.
625	One complete order of colours, together with the reddish-yellow of the second order. The colours very faint.
1000	Four complete orders of colours.
1000	One complete order, with blue, green, and yellowish-green of the second order.
1250	One complete order, with blue and bluish-green of the second order. The colours very faint.
2000	One complete order, together with blue, green, and greenish-yellow of the second order.
2500	One complete order, together with the full blue of the second order.
3333	Gamboge-yellow of the first order.
5000	One complete order, together with bluish-white of the second order.
10,000	One complete order, with blue and fainter blue of the second order.

In the third specimen, with 1000 grooves, mentioned in this table, the following were the four orders of colour:—

Colours.	Angles of incidence.
White	90° 0′
Yellow	80 0½
Reddish-orange	77 0½
Pink	76 20
Junction of pink and blue	75 40
Brilliant blue	74 30
Whitish	71 0
Yellow	64 45
Pink	59 45
Junction of pink and blue	58 10
Blue	56 0
Bluish-green	54 30
Yellowish-green	53 15
Whitish-green	51 0
Whitish-yellow	49 0
Yellow	47 15
Pinkish-yellow	41 0
Pink-red	36 0
Whitish-pink	31 0
Green	24 0
Yellow	10 0
Reddish	0 0

These colours are obviously analogous to those of the reflected rings in thin plates, though with a white centre, but they *have not the same composition.* By turning the system of lines round in azimuth, the same colours are seen at the same angles of incidence, and they suffer no change either by varying the distance of the luminous aperture, or the distance of the eye of the observer.

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Desirous of seeing what effect would be produced when the original surface of the steel was almost wholly removed, Sir John Barton executed for Sir D. Brewster a specimen with 2000 grooves in an inch, in which this was nearly effected. Unfortunately, however, the diamond point which he used broke before he had executed any considerable space, and the experiments, therefore, with so small a portion, were less complete than could have been desired.

The specimen, however, gave four orders of colours, which were developed at greater angles of incidence than in the preceding table. The following were the results:—

Colours.	Angles of incidence.
White	90° 0′
Straw-yellow	
Faint red	
Pink	
First limit of pink and blue	80 0
Blue	
Green	
Yellow	
Red	
Pink	
Second limit of pink and blue	69 40
Blue	
Green	
Yellowish-green	
Yellow	
Orange	
Scarlet	
Purple	
Third limit of pink and blue	48 0
Blue	
Brilliant green	
Yellowish-green	
Yellow	
Reddish	10 0

The property established by the preceding experiment is certainly one of a very remarkable kind. That a pure and highly-polished metallic surface, which reflects light perfectly white, should actually decompose it when the surface is reduced to narrow lines, is inconsistent with every doctrine respecting light. Here there are no rays to interfere, no doubly-refracted pencils, and, in short, none of the ordinary conditions on which the decomposition of light depends. That the colour does not arise from light that has entered a certain way into the body interfering with that which is regularly reflected, is obvious from the fact, that in two specimens of 2000 grooves in an inch, impressed on *black* wax, the new colours were very distinct, the vertical tint being a greenish-yellow of the second order in one specimen, and a gamboge-yellow in the other, in addition to one complete order of colours at greater incidences.

The following experiments, intended to show the effect of a variable refracting power in the reflecting surface, are calculated to give us some insight into the nature of this new property of light. In the following table Sir David Brewster has described the changes produced upon the colours, by placing different fluids on the reflecting surface:—

No. of grooves in an inch.	Maximum vertical tint without a fluid.	Maximum tint with three different fluids.
312½	No colour	1. Water—tinge of yellow. 2. Alcohol—tinge of yellow. 3. Oil of cassia—faint reddish-yellow.
500	Citron-yellow of first order	1. Water—tinge of red. 2. Alcohol—diluted pink. 3. Oil of cassia—a bluer pink.
625	Reddish-yellow of second order	1. Water—faint pink of second order. 2. Alcohol—ditto more pink. 3. Oil of cassia—bluish-pink of second order.
1000	Yellowish-green of second order	1. Water—pinkish-red, second order. 2. Alcohol—brilliant pink, ditto. 3. Oil of cassia—greenish-blue, third order.
1250	Bluish-green, faint	1. Water—yellow, second order. 2. Alcohol—yellower. 3. Oil of cassia—yellowish-pink.

Periodical Colours.

No. of grooves in an inch.	Maximum vertical tint without a fluid.	Maximum tint with three different fluids.
2,000	Greenish-yellow, second order	1. Water—brownish-red, second order. 2. Alcohol—pinkish-red, ditto. 3. Oil of cassia—greenish-blue.
2,500	Blue, second order	1. Water—dilute-green. 2. Alcohol—greenish-white, second order. 3. Oil of cassia—bright gamboge-yellow.
3,333	Gamboge-yellow, first order	1. Water—pinkish-red, first order. 2. Alcohol—reddish-pink. 3. Oil of cassia—bright blue, second order.
5,000	Bluish-white, second order	1. Water—pale yellow. 2. Alcohol—yellow, with tinge of orange. 3. Oil of cassia—yellowish-pink, second order.
10,000	Fine blue, second order	1. Water—greenish-white, second order. 2. Alcohol—yellowish-white. 3. Oil of cassia—brilliant gamboge-yellow.

Similar results were obtained with grooves impressed upon wax; hence it follows that more orders of colours, and higher tints, at a given incidence, are developed by diminishing the refractive power of the grooved surface. But one of the most interesting results in this table is the part in which the colours are entirely developed by the fluids applied to the surface; and hence if we had transparent fluids of much higher refractive powers, the colours would be produced when the intervals were much larger.

Similar phenomena were developed when the grooves were impressed on the fusible metal, on tin, and on isinglass. In those on isinglass, the new colours were seen also in the transmitted central image, and were extremely brilliant; but they were not decidedly complementary to those in the reflected image. The following were the colours of the reflected and transmitted image in isinglass, beginning from 90° of incidence:—

Colour of the reflected central image.	Colour of the same image, seen by transmission.
Yellow	Deep blue.
Orange	Paler blue.
Pink	Blue.
First limit of pink and blue	Blue.
Blue	Pink.
Green	Orange-pink.
Yellow	Orange.
Orange	Yellow.
Pink	Yellow.
Second limit of pink and blue	Yellow.
Blue	Yellow.

Sir D. Brewster was now desirous of observing what took place in the prismatic images, when the colours appeared in the principal or central image.

Let AB (fig. 119) be the reflected image of a long rectangular aperture from the spaces between the grooves, and ab, $a'b'$, $a''b''$, $a'''b'''$, the prismatic images of it; vv, $v'v'$, &c., being the violet sides, and rr, $r'r'$, &c., the red sides of these spectra. Then, in the

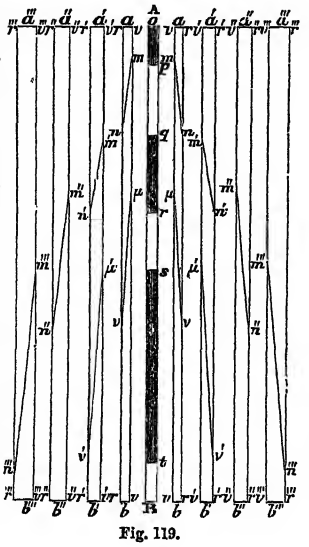

Fig. 119.

First spectrum ab, the *violet* rays are obliterated at m at an incidence of 74°, and the *red* rays at n, at an incidence of 66°, the intermediate colours, blue, green, being obliterated at intermediate points between m and n, and at angles of incidence intermediate between 74° and 66°. In the

Second spectrum $a'b'$, the *violet* rays are obliterated at m' at an incidence of 66° 20′, and the *red* at n' at 54° 45′. In the

Third spectrum $a''b''$, the *violet* rays are obliterated at m'' at 57°, and the *red* at n'' at 41° 35′. And in the

Fourth spectrum $a'''b'''$, the *violet* rays are obliterated at m''' at 48°, and the *red* rays at n''' at 23° 30′.

Another similar succession of obliterated tints takes place on all the prismatic images at a lesser incidence, as shown at $\mu\nu$, $\mu'\nu'$, the violet being obliterated at μ, and the *red* at ν, and the intermediate colours at intermediate points. In this second succession the line $\mu\nu$ begins and ends at the same angle of incidence as the line $m''n''$ in the third prismatic image $a''b''$; and the line $\mu'\nu'$ on the second prismatic image corresponds with $m'''n'''$ on the fourth prismatic image.

This singular obliteration of the colours is shown more clearly in fig. 120, where $rmvn$ is a part of one of the prismatic images, rr the red space, gg the green space, bb the

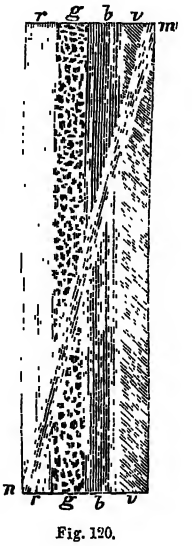

Fig. 120.

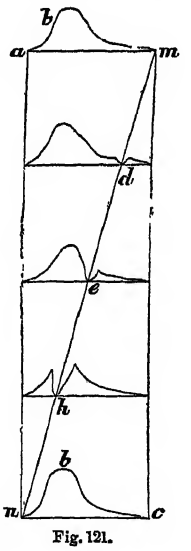

Fig. 121.

blue, and vv the violet space. The line of obliteration mn begins at m, the extreme violet being obliterated there, so that the curve of illumination abm (fig. 121) is just affected at one extremity m. The line advances into the spectrum, and at the point corresponding to d (fig. 121) a portion of the blue and violet is obliterated, as shown by the notch in the curve; at e, a portion of the green and blue; at h, a portion of the red and green; and at n the extreme red.

A similar obliteration of tints takes place on the ordinary image AB.

The first obliteration—viz., that of the violet—takes place at o (fig. 119), and that of the red at p; while the intermediate colours disappear at intermediate points. This first space of obliteration has no corresponding one at the same incidence in any of the prismatic images.

The second obliteration of the violet in AB takes place at q, and that of the red at r, and this corresponds in inci-

Periodical Colours.

dence with the obliterations $m'n'$, $m'n'$ on the second prismatic image.

The third obliteration of the violet takes place at s, and that of the red at t, and this corresponds in incidence with the four obliterations on the second and fourth prismatic images—viz., $\mu\nu$, $\mu'\nu'$, $m''n''$, $m'''n'''$.

In all these phenomena the points m, n, μ, ν, &c., are only the points of minimum intensity, or of maximum obliteration; for the tints never entirely disappear, and those obliterated at each line mn form an oblique spectrum containing all the prismatic colours.

The analysis of these curious and apparently complicated phenomena becomes very simple when they are examined under homogeneous illumination. The effect produced in red light is represented in fig. 122, where AB is the image of the rectangular aperture reflected from the faces n of the steel, and the four images on each side of it correspond with the prismatic images. All these nine images, however, consist of homogeneous red light, which is obliterated at the fifteen shaded rectangles, which are the minima of the new series of periodical colours which cross both the ordinary and the prismatic images. The centres p, r, t, n, ν, &c., of these rectangles correspond with the points marked with the same letters in fig. 119; and if we had drawn the same figure for violet light, the centres of the rectangles would have corresponded with o, q, s, m, μ, &c., in fig. 119. The rectangles should have been shaded off to represent the phenomena accurately, but the only object of the figure is to show to the eye the position and relations of the minima of the periods.

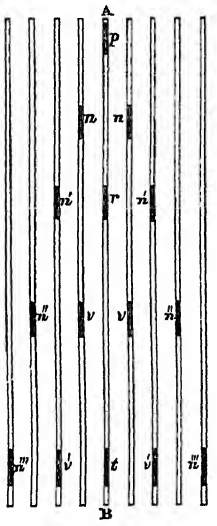

Fig. 122.

If it should be practicable to remove a still greater portion of the faces n, the first minimum p (fig. 122), would commence at a greater angle of incidence; and other two rows of minima—namely, rows of five and six—would be found extending to the fifth and sixth prismatic images. The arrangement and succession of these is easily deducible from fig. 122, where the law of the phenomenon is obvious to the eye.

The following table contains the angles of incidence reckoned from the perpendicular at which these minima occur in the extreme rays:—

Position of the Minima in Red Light.

	Ord. Im.	1st Prism Im.	2d Prism Im.	3d Prism Im.	4th Prism Im.
First minima, p	76° 0′	66° 0′	55° 45′	41° 35′	23° 30′
Second minima, r	55 45	41 35	23 30	...	...
Third minima	23 30	...	...	...	...

Position of the Minima in Violet Light.

	Ord. Im.	1st Prism Im.	2d Prism Im.	3d Prism Im.	4th Prism Im.
First minima	81° 30′	74° 0′	66° 20′	57° 0′	48° 0′
Second minima	66 20	57 0	48 0	...	...
Third minima	48 0	...	...	...	...

When the steel with 1000 grooves is exposed to common light, and the incident ray is very near the perpendicular, the 5th, 6th, 7th, and 8th prismatic images are combined into a mass of whitish light, terminated externally by a black space. As the angle of incidence increases, the 6th, 7th, 8th, and 9th images are combined into this mass, then the 7th, 8th, 9th, and 10th images, and so on; the black space which terminates this mass receding from the axis or image AB (fig. 119), as the obliquity of the incident ray increases. Periodical Colours.

Having covered the steel plate with water and oil of cassia in succession, the angular distances of the black space were found to be as follows at the same incidence:—

Air	12° 23′
Water	17 15
Oil of cassia	21 22

the sines of which are inversely as the indices of refraction of the fluids.

Phenomena analogous to those above described take place on the grooved surfaces of gold, silver, and calcareous spar, &c.

In order to study this subject under a more general aspect, it was desirable to examine the phenomena exhibited by grooved surfaces of different refractive powers. It was obviously impossible to procure systems of lines upon transparent bodies in which the grooves should have exactly the same distance and magnitude; but Sir D. Brewster conceived it practicable to impress upon different substances the very grooves which produced the preceding phenomena, and he succeeded in impressing the system of 1000 grooves upon tin, realgar, and isinglass.

The following results were obtained with *tin*, the colours being those upon AB, fig. 119:—

White	90° 0′
Yellow	
Pink	
First junction of pink and blue	76 20
Greenish-blue	
Yellow	
Pink	
Second junction of pink and blue	57 40
Bluish-green	
Yellow	
Orange	
Pink	
Third junction of pink and blue	
First minimum of red	76 0
Second „ „	61 0

The following results were obtained with *realgar*:—

White	90° 0′
Yellow	80 0
Pink	75 30
First junction of pink and blue	73 10
Blue	72 0
Bluish-green	70 15
Yellow	63 0
Bright pink	54 0
Second junction of pink and blue	47 0
Bluish-green	41 0
Yellow	36 0
Pink	32 0
More and more pink	
First minimum of red	72 0
Second „ „	61 15

The following results were obtained with *isinglass*. The colours were generally the same as in the steel:—

The first limit of pink and blue was at	75° 45′
The blue of second order	73 45
The second limit of pink and blue was at	54 30

In these experiments the tin gave nearly the same results as the steel; but in the realgar and the isinglass similar tints were produced at a less angle of incidence than in the steel. The minima of the periods were exhibited very finely on the isinglass, and were produced at smaller angles of incidence.

In a specimen with 1000 grooves upon isinglass, the third pink, or that seen upon steel at 36°, was the highest; but after drying, the pink descended to yellow, and subsequently to green.

If the isinglass is removed from the steel when it is still soft, the edges of the grooves get rounded and lose their

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sharpness, and only one prismatic image is seen on each side of the ordinary image, as in mother-of-pearl.

The mass of white light is finely seen in the impressions taken upon tin, but never appears upon isinglass.

The prismatic colours seen on mother-of-pearl are exactly of the same kind as the prismatic images of grooved surfaces, with this difference, that a single prismatic image only is seen on each side of the common colourless image. The following account of these colours has been given by Sir David Brewster, who first analyzed them, and discovered their communicability to wax, the fusible metals, &c. :—

Properties of mother-of-pearl.

Mother-of-pearl, which constitutes the interior lining of the shell of the pearl oyster, and of various other shells, has been long employed in the arts for the purposes of use and of ornament. Every one must have observed the play of prismatic tints, from which this substance derives much of its value as an ornament; but the nature and origin of these tints were never made the subject of investigation till Sir David Brewster took up the subject, and published the results of his observations in the *Phil. Trans.* for 1814.

In order to study well the properties of this substance, we must select a regularly-formed piece or plate of mother-of-pearl, which is known by the uniformity of its colour in daylight, and scarcely exhibits in that light any of the prismatic tints. Let this plate be now ground flat on both sides (but not polished) upon a hone or piece of slate, or upon a bit of glass, with the powder of schistus, or with fine emery. When this is done, hold the plate close to the eye, and view in it by reflection the flame of a candle, or of an Argand lamp, or the flame of two or three candles, so placed as to appear like one, and we shall see a dull and reddish image, free from all prismatic colours, its dulness arising from the imperfect polish of the surface. On one side of, or above or below this image, will be seen a brighter image, with the colours of the spectrum, nearly as if it had been formed by a prism.

When the plate of mother-of-pearl is turned round in its own plane, the prismatic image will follow the motion of the plate, and revolve round the common image, the *blue* rays being nearest the common image, and the *red* rays farthest from it. If the plate is so placed that the prismatic image is in the plane of reflection, and between the common image and the observer, it will be found that the distance between the two images increases with the angle of incidence, being about 2° 7′ at an incidence not far from the perpendicular, and 9° 14′ at a very great obliquity. This distance between the images varies more rapidly when the plate is turned round 180° in azimuth, so that the common image is between the prismatic image and the observer; but in this case we cannot measure the angle accurately much beyond 60°, when it is nearly 4° 30′.

Beyond the prismatic image, and in the same line with it and the common image, will be observed a mass of coloured light, nearly as far beyond the prismatic image as the prismatic image is from the common image. The distance of this patch of coloured light varies according to a different law from that of the prismatic image, as the rays which form it have previously suffered refraction. This mass of light has a beautiful *crimson* colour at great angles of obliquity.[1]

Hitherto we have considered the phenomena only when the surface has that degree of polish which accompanies smooth grinding. If a greater degree of polish, however, is communicated to the plate, the common image becomes more brilliant, and *a new prismatic image starts up, diametrically opposite to the first prismatic image, and at the same distance from the common image.* This second prismatic image resembles in every respect the first. Its brilliancy increases with the polish, and when this polish is very high, the second prismatic image is nearly as bright as the first, which has its brilliancy a little impaired by polishing. This second image is never accompanied, like the first, by a mass of coloured light. If the polish of the surface is removed by grinding, the second prismatic image vanishes, and the first resumes its primitive brilliancy.

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When the preceding experiments are repeated on the opposite surface of the plate of mother-of-pearl, the same phenomena are observed, but in a *reverse* order, the first prismatic image and the mass of coloured light being now seen on the opposite side of the plate.

Its reflected colours communicable.

In measuring the angular distances of the prismatic image from the common image seen by reflection, Sir David Brewster had occasion to fix the mother-of-pearl to a goniometer by means of a cement made of rosin and bees'-wax. Upon removing it from the cement, by insinuating the edge of a knife, and making it spring off, the plate of mother-of-pearl left a clean impression of its own surface; and he was surprised to observe that the cement had actually received the property of producing the colours which were exhibited by the mother-of-pearl. This was at first attributed by Sir D. Brewster, and others who saw the experiments, to a very thin film of mother-of-pearl detached from the plate, and left upon the cement; but subsequent experiments convinced him that the mother-of-pearl communicated to the cement its own properties.

The properties of mother-of-pearl may also be communicated in this way to *balsam of tolu, gum-arabic, gold-leaf* placed upon wax, *tinfoil, fusible metal* composed of bismuth and mercury, and to *lead*, by hard pressure, or the blow of a hammer. When the impression is first made upon the *fusible metal*, the play of colours is singularly fine; but the metallic surface soon loses its polish, and the colours gradually decay.

If dissolved *isinglass* or *gum-arabic*, &c., is placed upon the plate of mother-of-pearl, and allowed to harden upon it, they will exhibit in the most splendid manner the colours of the substance; or if we indurate these gums between two plates of mother-of-pearl, we shall have transparent films, exhibiting on both sides the play of the prismatic tints.

If we now examine the prismatic images *reflected* from the wax which has received the impression from an unpolished piece of mother-of-pearl, we shall find that the single prismatic image which is thus produced is on the *right hand* of the common image, whereas it is on the *left hand* of the common image in the mother-of-pearl itself.

At different angles of incidence, the two coloured images formed by the wax follow the same laws as those produced by the mother-of-pearl; but the mass of *green* and *crimson* tints never appears in the impressions taken from mother-of-pearl, because they are produced by light which has penetrated the mother-of-pearl, and has after refraction been reflected from one or more thin plates which lie between the strata of which the mother-of-pearl is composed.

Transmitted colours

In communicating to *isinglass* or *gum-arabic* the superficial structure of mother-of-pearl, their transparency enables us to observe the phenomena of the transmitted colours. The two prismatic images were both visible—the primary one being remarkably brilliant, and the second one scarcely perceptible; but when the light was transmitted through the gum, the primary image was nearly extinct, while the secondary one was unusually brilliant and highly coloured, far surpassing in splendour those which are formed by transmission through the mother-of-pearl itself. When both the surfaces of isinglass or gum-arabic have received the superficial structure of mother-of-pearl, four images are seen.

[1] See *Phil. Trans.* 1836, p. 55.

Periodical Colours.

From these facts it is obvious that the principal phenomena of mother-of-pearl have their origin in a particular configuration of its surface. By the use of the microscope Sir David Brewster discovered in every specimen of mother-of-pearl that gave the prismatic images a grooved structure upon its surface, resembling the delicate texture of the skin at the tip of an infant's finger, or the lines which mark out islands and coasts upon a map.

In many specimens of mother-of-pearl the grooves are parallel, but they are often arranged in all possible directions like the veins of agate, and in this case the common reflected image is surrounded with a number of prismatic images, sometimes arranged in a circular or oval form more or less regular. Sometimes the spaces between the grooves, or rather the edges of the strata of the shell, can be seen by the naked eye, or by a magnifying power of six or eight times, in which case the prismatic images are less highly coloured, having whitish light in their centre, and are placed close to the common image. At other parts of the same plate more than 3000 grooves may be counted in an inch, and in some places they cannot be detected by ordinary magnifying powers.

The direction of the grooves is always at right angles to the line joining the common image and the prismatic image. Had the grooved structure appeared only upon its external surface, the phenomena and the communicable colours would have disappeared when the surface was ground down; but the surprising part of the phenomena is, that if we grind down the external surface with the finest powders, and polish it to the utmost degree, we never can grind out the grooved structure, and replace it by a flat surface. The edges of the shell break off by the action of the finest powders, so that the termination of one stratum cannot pass into the subjacent stratum without being separated by a distinct line or edge, formed by the fracture of its thin marginal parts. As all the strata have thus a prismatic termination, the mass of green and crimson light is reflected from near the edge of the surface upon which the superincumbent stratum lies.

Observations of Sir John Herschel.

Sir John Herschel discovered in very thin plates of mother-of-pearl a pair of nebulous prismatic images more distant from the central image than the two prismatic ones above described, and also a pair of fainter nebulous images, the line joining which is perpendicular to the line joining the first pair. He saw them by looking through thin pieces between the 70th and 300th of an inch thick. They are produced by a veined structure, in which there were 3700 veins in an inch. They cross the common grooves at all angles, and are parallel to the plane passing through the centres of the two systems of the coloured rings.

In applying apertures of various figures to the mirrors and object-glasses of telescopes, Sir John Herschel obtained the following results:—

Effects produced by apertures of various shapes.

With the largest circular diaphragm, either near to or distant from the spectrum or object-glass, the disc and rings increase inversely as the diameter of the aperture. When the aperture was only 1 inch in a telescope of 7 feet in focal length, the disc of the star was well defined, and surrounded with one ring only faintly tinged with *white*, faint *red*, *black*, very faint *blue*, *white*, extremely faint *red*, and *black*, reckoning from the centre. With a half-inch aperture, the rings were invisible, the disc greatly enlarged, the light shading off to the circumference like some comets. This is shown in fig. 123.

Fig. 123.

With annular apertures the phenomena were highly beautiful. When the outside of the annulus was 3 inches, and the inside $1\frac{1}{4}$, *Capella* appeared as in fig. 124, and the double star *Castor* as in fig. 125. When the breadth of the annular aperture is diminished, the disc and the breadth of the rings also diminish, while the number of visible rings increases. The appearance of Capella with annular apertures of 5·5 inches exterior and 5·5 interior, of 0·7 exterior and 0·2 interior, and of 2·2 exterior and 2·0 interior, is represented in figs. 126, 127, and 128. In the last figure the disc was reduced to a point, and the rings were so numerous and close that they could scarcely be counted. When the breadth of this annulus was reduced one-half, the rings were invisible.

Periodical Colours.

Fig. 124.

Fig. 125.

Fig. 126.

Fig. 127.

Fig. 128.

When two annuli, as shown in fig. 129, were used, large halos or rings were seen by Sir John Herschel, as in fig. 130.

With an aperture of the shape of an equilateral triangle, or the opening between two concentric equilateral triangles, the figure was that shown in fig. 131, in which the small central disc was extremely bright, and the field of the telescope black.

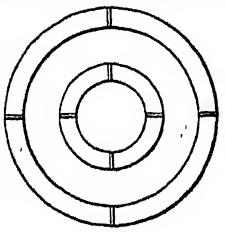

Fig. 129.

When fig. 131 is seen with the telescope out of focus, it changes into fig. 132.

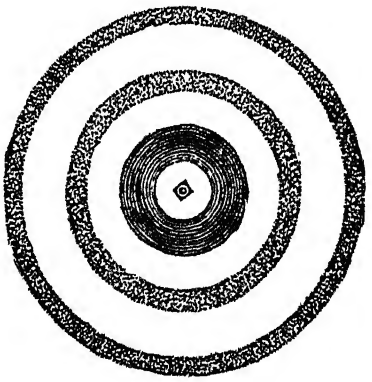

Fig. 130.

When three circular apertures are placed at the angles of an equilateral triangle, the effect shown in fig. 133 is produced.

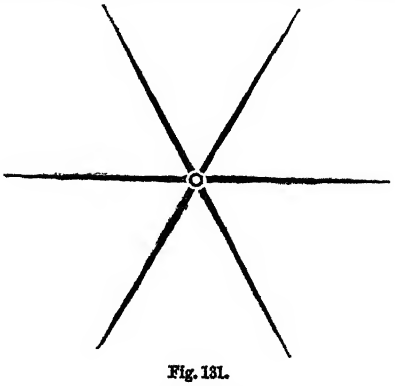

Fig. 131.

Periodical Colours.

When three equal and similar annular apertures were arranged in the same manner, the effect was as in fig. 124.

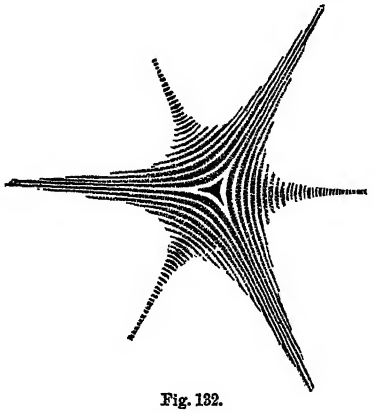

Fig. 132.

When this was thrown out of focus, it had the appearance

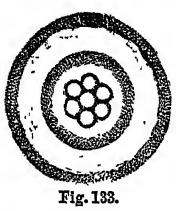

Fig. 133.

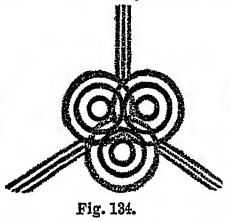

Fig. 134.

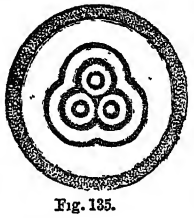

Fig. 135.

in fig. 134; when brought better into focus, it changed into fig. 135; and when in focus, into fig. 124.[1]

Sect. IV.—On the Colours of Concave Mirrors or thick Plates.

Colours of thick plates.

The colours produced by thick plates were discovered by Sir Isaac Newton, who has given the following account of them:[2]—"There is no glass or speculum, however well polished, but besides the light which it refracts or reflects regularly, scatters every way irregularly a faint light by means of which the polished surface, when illuminated in a dark room by a beam of the sun's light, may be easily seen in all positions of the eye. The sun shining into my darkened chamber through a hole in the shutter AB (fig. 136), one-third of an inch wide, I let the intromitted beam

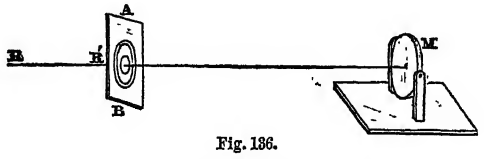

Fig. 136.

of light RR′ fall perpendicularly upon a glass speculum M, ground concave on one side and convex on the other, to a sphere of 5 feet and 11 inches radius, and quick-silvered over on the convex side; and holding a white opaque chart at the centre of the sphere to which the speculum was ground, in such a manner that the beam of light might pass through a little hole made in the middle of the chart to the speculum, and thence be reflected back to the same hole, I observed upon the chart four or five concentric rings of colours like rainbows. If the distance of the chart from the speculum was much greater or much less than that of 6 feet, the rings became dilute and vanished.

"The colours of these rainbows succeeded one another from the centre outwards in the same form and order with those transmitted through the two object-glasses.

"The diameters of the first four of the bright rings, measured between the brightest parts of their orbits at the distance of 6 feet from the speculum, were $1\frac{11}{16}$, $2\frac{3}{8}$, $2\frac{11}{12}$, $3\frac{3}{8}$ inches, whose squares are in arithmetical progression of the numbers 1, 2, 3, 4. If the white circular spot in the middle be reckoned amongst the rings, and its central light, where it seems to be most luminous, be put equipollent to an infinitely little ring, the squares of the diameters of the rings will be in the progression 0, 1, 2, 3, 4, &c. I measured also the diameters of the dark circles between these luminous ones, and found their squares in the progression of the numbers $\frac{1}{2}$, $1\frac{1}{2}$, $3\frac{1}{3}$, &c.; the diameters of the first four at the distance of 6 feet from the speculum being $1\frac{3}{16}$, $2\frac{1}{16}$, $2\frac{3}{8}$, $4\frac{3}{20}$ inches. If the distance of the chart from the speculum was increased or diminished, the diameters of the circles were increased or diminished proportionally.

"When the beam of the sun's light was reflected back from the speculum, not directly to the hole in the window, but to a place a little distant from it, the common centre of that spot, and of all the rings of colours, fell in the middle way between the beam of the incident light and the beam of the reflected light, and by consequence in the centre of the spherical concavity of the speculum, whenever the chart on which the rings of colours fell was placed at that centre. And as the beam of reflected light, by inclining the speculum, receded more and more from the beam of incident light, and from the common centre of the coloured rings between them, these rings grew bigger and bigger, and so also did the white round spot, and new rings of colours emerged successively out of their common centre, and the white spot became a white ring encompassing them; and the incident and reflected beams of light always fell upon the opposite parts of this white ring, illuminating its perimeter like two mock suns in the opposite parts of an iris. * *

"The colours of the new rings were in a contrary order to those of the former, and arose after this manner. The white round spot of light in the middle of the rings continued white to the centre, till the distance of the incident and reflected beams at the chart was about $\frac{7}{8}$ parts of an inch, and then it began to grow dark in the middle. And when that distance was about $1\frac{2}{6}$ of an inch, the white spot was become a ring encompassing a dark second spot, which in the middle inclined to violet and indigo. * *

"When the distance between the incident and reflected beams of light became a little bigger, there emerged out of the middle of the dark spot after the indigo a blue, and then out of that blue a pale green, and soon after a yellow and red. * *

"When the distance of the two beams of light at the chart was a little more increased, there emerged out of the middle in order after the red, a purple, a blue, a green, a yellow, and a red inclining much to purple."

The Duke de Chaulnes[3] observed colours analogous to those of thin plates, when the surface of a mirror was covered with a thin film of milk after it was dry, or with a screen of gauze or muslin placed at a small distance in front of the mirror. Sir William Herschel[4] has given an account of an interesting experiment, in which, by dispersing hair-powder in the air before a metallic speculum on which a beam of light is incident, and receiving the reflected beam on a screen, fine rings of colour are produced; or an analogous phenomena may be seen by scattering hair-powder on the face of a common looking-glass.[5]

Sir David Brewster has remarked,[6] that the method which he has found the most simple for exhibiting these colours, is to place the eye immediately behind a small flame, from a minute wick fed with oil or wax, so that we can examine

[1] Sir John Herschel's *Treatise on Light*, § 769, &c., in which the reader will find the subject more fully treated.
[2] This account is abridged from Newton's *Optics*, book ii., part iv., p. 264.
[3] *Mém. de l'Acad. de Paris*, 1705, p. 136.
[4] *Phil. Trans.* 1807, part ii.
[5] See our art. Chromatics, § ix., vol. vi.
[6] *Treatise on Optics*, p. 131, § 80.

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them even at a perpendicular incidence. The colours of thick plates may be seen even with a common candle held before the eye at the distance of ten or twelve feet from a common pane of crown-glass in a window that has accumulated a little fine dust upon its surface, or that has on its surface a deposition of fine moisture. Under these circumstances they are so very bright, that they may be seen even when the pane of glass is clean.

Sect. V.—On the Colours Produced by Double Plates of Glass of Equal Thickness.

Colours of double plates of equal thickness.

In 1815 Sir David Brewster published in the *Edinburgh Transactions*[1] "An account of a new species of coloured fringes produced by the reflection of light between two plates of parallel glass of equal thickness."

In these experiments he cut the plates of glass AB, CD (fig. 137) out of the same piece, and having placed between them a bit of soft bees'-wax, he pressed them together till they were at the distance of nearly the tenth of an inch, and slightly inclined to each other as in the figure, till one or more of the reflected images of a circular luminous disc seen in the direction VR by an eye at V, were reflected from the bright and direct image formed by transmitted light. When this was done, the reflected image was crossed with about fifteen or sixteen beautiful parallel fringes. The three central fringes consist of blackish and whitish stripes, and the exterior ones of brilliant stripes of red and green light; and the central fringes have the same appearance in relation to the external fringes as the internal have to the external rings formed by thin plates. If the two plates of glass are turned round in a plane at right angles to the incident ray, the reflected images will move round the bright image, and the parallel fringes will always preserve a direction at right angles to a line joining the centres of the bright and reflected images. Hence it follows, *that the direction of the fringes is always parallel to the common section of the four reflecting surfaces which exercise an action upon the incident light.*

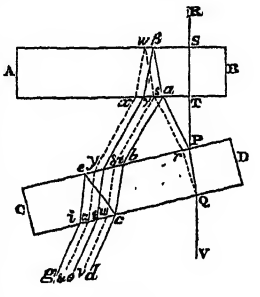

Fig. 137.

The position of the plates remaining as before, let the inclination of the plates, or, what is the same thing, the distance of the bright and the reflected image, be varied by a gentle motion of one of the plates, *the coloured fringes will be found to increase in breadth as the inclination of the plates is diminished, and to diminish as the inclination of the plates is increased.*

If the light of the circular object, instead of falling perpendicularly upon the plates, is incident at different obliquities, so that the plane of incidence is *at right angles to the common section of the plates*, no fringes are visible across any of the images. But if the plane of incidence is *parallel to the common section of the plates*, the reflected images increase in brightness with the obliquity of incidence, and the coloured fringes become more vivid. When the angle of incidence increases from 0° to 90°, the images that have suffered the greatest number of reflections are crossed by other fringes, inclined to them at a small angle. At an angle of about 44°, the image formed by four reflections is covered with interfering fringes; but it is not till the angle of incidence is greater that this is distinctly seen on the image formed by two reflections.

Hitherto he had observed no fringes upon the first or bright image, which is composed of light that has not suffered reflection from the second plate of glass. By concealing, however, the bright light of the first image, so as to perceive the image formed by a *second* reflection within the first plate, and by viewing this image through a small aperture, which he found of great service in giving distinctness to all the phenomena, he observed fringes across the first image far surpassing in precision of outline, and in richness of colouring, every analogous phenomenon which he had seen. When these fringes were concealed, he also observed other fringes on the image immediately behind them, and formed by a *third* reflection, from the interior of the first plate. He concealed the second image, upon which the fringes were extremely bright, and very faint stripes were seen upon the one immediately behind it.

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In examining these phenomena a little more attentively, he observed that the size of the fringes in the first image varied with the distance of the eye from the plates, while those on the second and fourth image diminished with that distance.

In pursuing this inquiry, Sir David Brewster found *that the production of the fringes depends upon the action of all the four surfaces of the two plates of parallel glass; and that the magnitude of the fringes are inversely as the thickness of the plates that produce them at a given inclination.*

When the eye is placed between the plates and the luminous object so as to see the *first, third, fifth, seventh*, &c., reflected images, the coloured fringes are also seen, and have the same character as those already described.

In order to explain the changes which the light undergoes in its passage through the plates of glass, let AB, CD (fig. 137) be a section of two plates at right angles to the common section of their surfaces, and let RS be a ray of light incident nearly in a vertical direction. This ray, after passing through the first plate AB, will suffer a small refraction at P and Q, and emerge in the direction QV parallel to RS. At the point P, in the second plate CD, the ray TP will be reflected to *a*, again reflected to *b*, and after suffering a refraction at *b* and *c*, will emerge in the direction *cd*, forming with RV an angle equal to twice the inclination of the plates. A portion of the reflected ray P*a* will enter the first plate at *a*, and having suffered reflection and refraction at β, the reflected portion $\beta\gamma$ will reach the eye at θ. The ray P*abc* will likewise suffer a reflection at *c* and *e*, and will reach the eye at *g*. In like manner, a part of the ray PQ will be reflected at Q, and move in the direction Q*rstuv*, and another part of it in the direction *swxyz*, and these rays will suffer several other reflections; but the images which they form will be so faint, that the eye will not be capable of perceiving them. When the observer, therefore, looks at a luminous body, in the direction SR, through the glass plates, he will perceive two images, one of which is a bright image, seen by the transmitted light QV, and the other is a faint image, seen principally by the reflected light P*abcd*, and composed of several images, formed by the pencils *cd*, *uv*, $\epsilon\theta$, $z\delta$, and *ig*. The bright image is not crossed by coloured fringes, but the fringes appear distinctly upon the other image; and the light by which these fringes are formed has suffered two reflections from the exterior surfaces, and two refractions at the interior surfaces of the plates.

Dr Thomas Young, in the article Chromatics in this work,[2] has given an explanation of these phenomena upon the principles of interference; and Sir John Herschel has shown, by an interesting analysis of them, that they are well fitted for illustrating the laws of this class of phenomena, and may be readily explained by interference.[3]

Fringes in achromatic object-glasses.

When two or three plates are combined, as in the form of concave and convex lenses, and are combined as in the double and triple achromatic object-glass, a series of beauti-

[1] Vol. vii., p. 435. [2] § 6, vol. vi. [3] *Treatise on Light*, §§ 688–696. See also Biot's *Traité de Physique*, tom. iv., p. 246.

Periodical Colours.

ful systems of rings are developed. The method of observing these rings, and by which Sir David Brewster discovered them, is shown in fig. 138, where ABCD is the

Fig. 138.

section of the object-glass, including a meniscus of air. A small flame S is placed about four or five inches from the object-glass, and a small screen G is interposed between the flame and the eye at E, which is kept as close to S as possible. The distance of the object-glass is then varied, till the inverted greenish-coloured flame reflected interiorly from the concave surface A1B seems to cover the whole area of the object-glass. When this takes place the rings may, by a slight change in the position of the object-glass, or by screening the image formed by reflection from A1B, be seen in the distinctest manner over the expanded but enfeebled image formed by a second reflection from the same surface.

When the flame is small, and the eye sees it projected against the centre of the object-glass, the rings form a concentric system (as shown in fig. 139), approaching closer and closer to each other, towards the circumference of the lens. Two of these rings *mmmm*, *nnnn*, were distinguished from the rest by their darkness, and by the whiteness of the light between them; and they are the bounding lines of four systems of fringes into which the general system subdivides itself by oblique reflection. In order to see this change, incline the object-glass so that the point A is farther from the eye than B,

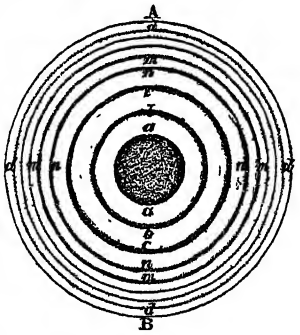


Fig. 139.

and so that the eye may receive the obliquely-reflected rays from every point of the surface A1B. At a slight deviation from the perpendicular, the rings become smaller and closer on the side A, and larger and more separated on the side B. At greater incidences the inner ring *aa* (fig. 139) contracts into an irregular crescent *aa* (fig. 140). The second and third rings *bb*, *cc* (fig. 139) do the same, as shown at *bb*, *cc* (fig. 140); and at a greater incidence the dark ring *nn* (fig. 139) assumes a similar form *nnnn* (fig. 140), and forms the boundary of the *remote central system*, *ncbaabcn*. In like manner, the lower part of the ring *nn* (fig. 139) has inclosed a smaller but similar system of rings, which are shown at *n'n'n'n'*, and may be called the *near central system*. While these changes are going on, the rings without *nn* (fig. 139) are undergoing analogous, though opposite, inflections. The outermost, *dddd* (fig. 139), divides itself into two unequal portions, which run out into

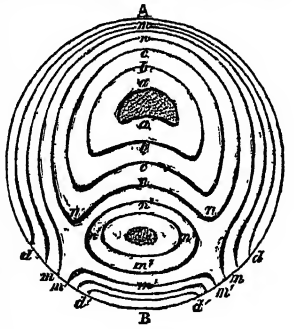


Fig. 140.

the circumference at the points *d*, *d*, *d*,' *d*' (fig. 140). Then the next ring,—viz., the dark one *mmmm* (fig. 139) forming the boundary of the *remote external system* mmmA, and of the *near central system* m'm'm'B (fig. 140). The four groups of rings thus developed assume at greater incidences the character shown in fig. 141, but they are not seen all at once; and in tracing their form it is necessary to cause the image on which they are produced to be reflected successively from different parts of the lens. The rings are so closely packed together, at a distance from the white centres *x*, *x*, to which they are all related, that it is extremely difficult to perceive them in the present object-glass. At a still greater angle of incidence, the rays close in upon the centres *x*, *x*, and become exceedingly close as the points *x*, *x* approach to the circumference of the lens, and the rays become brighter from the increase of the light at greater obliquities.

Periodical Colours.

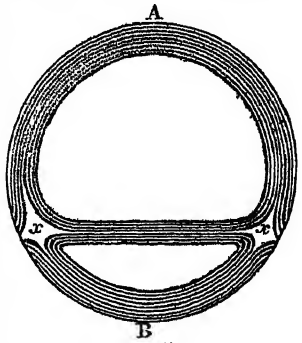


Fig. 141.

In some double object-glasses the rings can only be seen by looking through the convex crown-glass lens AB. In one object-glass the four bounding fringes at *x*, *x* (fig. 141) united and formed a black cross, as shown in fig. 142. From a series of experiments, Sir David Brewster has found that in the object-glass shown in fig. 138, the action of the two surfaces 1, 2 of the convex lens AB, and the inner surface 3 of the concave one CD, are necessary to the production of these fringes, and hence he concludes that the rings arise from the interference of two pencils of light, one of which has suffered *three* reflections within the convex lens AB, and has passed *four* times through its thickness, with another pencil which has suffered *two* reflections within the convex lens, and *one* reflection from the inner surface of the concave lens, and has passed *four* times through the thickness of the convex lens, and *twice* through the thickness of the meniscus of air.

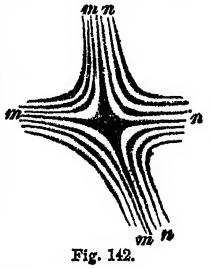


Fig. 142.

In a triple object-glass, which gave a system of rings similar to that in fig. 141, they were covered with *another system of very minute fringes*, parallel to one another, and to the line joining the centres *x* and *x*.[1]

Sect. VI.—On the Colours of Double Plates of Glass of Unequal Thickness, and other Analogous Phenomena.

Colours of double plates of unequal thickness.

Mr W. Nicholson observed the colours of thick plates in the glasses employed for the sights of sextants, and he considered them analogous to those of thin plates. They have been ascribed, however, by Dr Young,[2] "to the rays twice reflected in the second plate only."

Mr Knox.

Mr Knox of Belfast[3] described some interesting phenomena already briefly noticed by Dr Young in the article Chromatics. Having formed a system of the rings of thin plates, by placing a convex lens on a piece of silvered glass, he observed the common system of reflected rings, and also the transmitted system reflected to his eye by the silvered glass. This is shown in fig. 143, where A and B are the two systems; but he was surprised to observe between them a system of parallel fringes CDEF, passing

[1] *Edin. Trans.*, vol. xii., p. 191.

[2] Art. Chromatics, vol. vi., § 6.

[3] *Phil. Trans.* 1815, p. 161.

Periodical Colours.

through the intersection of the two circular systems. These fringes were equal in number to the number of the rings in A and B. They were equidistant, reached the edge of the lens on both sides, and were formed at right angles to the direction of the light, and to a line forming the centres of the systems A and B.

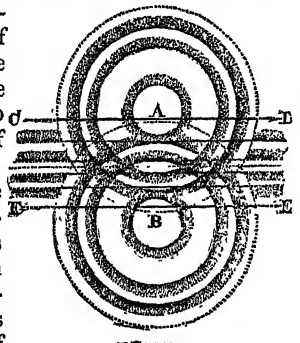


Fig. 143.

Mr Knox then tried the effect of combining two primary systems of reflected rings in the same manner. With this view, he placed a double-convex lens, about 36 inches in focal length, on a piece of plate-glass, with its under side painted black, and upon the lens he placed a piece of plate-glass. By these means two sets of primary rings were produced, whose relative positions could be altered at pleasure. By using the shadow of a black card, he found that, instead of parallel fringes as in fig. 143, he had a new species of rings of a circular form, from two to three times the diameter of the primary rings from which they originated. These rings passed, as before, through the intersections of the primary ones; and the ring which divided the two classes passed through a point, whose distance from the centre of each primary set was in proportion to their longest diameters.

These rings, which Mr Knox calls *intersectionary* ones, may be made to vary infinitely in their dimensions according as the diameters of the primary sets differ more or less, being least where that difference is greatest, and increasing in size as the two primary sets approach to equality, until at last they become straight lines, when the two primary sets are equal. The dimensions of the intersectionary rings will also, as Mr Knox remarks, *ceteris paribus*, diminish as the two primary sets approach, and increase as they recede from one another.

As these intersectionary rings are almost always accompanied by a second, and sometimes by a third set of equal or unequal dimensions, Mr Knox supposes that they may be produced by primary sets, combined with either transmitted or reflected sets, provided the two between which they are formed are of unequal dimensions.

Considering the intersectionary fringes as diagonals to the angles at which they were formed, Mr Knox conjectured that if he could form rectilineal fringes by flat plates, and combine them at different angles, he would produce a third or diagonal set placed between the other two. He accordingly took a pair of slips of glass, and by applying two of their ends together, and using some friction, and a considerable degree of pressure, he formed a fine set of rectilineal fringes. By applying a third slip of glass longitudinally to the upper one of the first two, he formed a similar set of rectilineal fringes at right angles to the first, and he immediately observed the diagonal fringes, which he had anticipated, appear in the angle between the two primary sets, as shown in fig. 144, where B and C are the primary fringes, and D the intersectionary set, divided into two classes, as shown by the dotted line. By forming the second set of fringes at different angles with the first, the central band of the intersectionary fringes always bisected the angle. It is a curious circumstance, that though the diagonal fringes are formed by the crossing of the two primary sets, yet they never appear at the opposite angle A, nor could they be made to appear in any angle formed by primary fringes, unless these fringes were so disposed as to have their red sides turned towards each other.

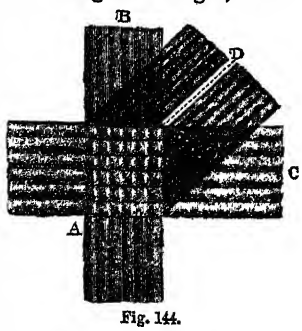


Fig. 144.

Periodical Colours.

Dr Young has given an explanation of these curious phenomena in the article CHROMATICS,[1] to which we must refer the reader.

Dr Young.

Mr Fox Talbot upon superposing two films of blown glass, and viewing through them a homogeneous yellow flame, and even the light of the sky, observed bright and dark stripes, or coloured bands and fringes, which were not produced by either of them separately. These phenomena, as Sir John Herschel remarks, are obviously referable to the same principle as the fringes discovered by Sir David Brewster, "the interference taking place here between rays respectively twice reflected within the upper lamina, and once reflected at the upper surface of the lower lamina, the interval between the glasses being supposed to be exactly equal to the thickness of the upper one, a condition which is sure to obtain somewhere when the laminæ are curved."[2]

Mr Fox Talbot.

Sect. VII.—On the Colours of Fibres formed by Reflection and Transmission.

Colours of fibres.

Every person must have observed the fine thread or line of the spider's web glittering with the brightest colours when the light of the sun is reflected from it to the eye. By examining these colours attentively, they are found to vary with the angle of incidence. The only attempt that we know of to explain this phenomenon that deserves notice is that of Sir John Herschel:—"These colours," says he, "may arise either from a similar cause (namely, that which produces colour in a single scratch or fissure, or the interference of light reflected from its opposite edges), or from the thread itself, as spun by the animal, consisting of several agglutinated together, and thus presenting not a cylindrical but a furrowed surface."

Spider's web.

On the Colours of Fibres by Transmitted Light.

Colours of fibres by transmitted light.

If we take a number of fibres of wool, and fix them in parallel directions, as in Fraunhofer's gratings, they will of course produce parallel spectra or coloured bands similar to those already described. If we take a mass of the same wool, in which the fibres have every possible direction, they will then exhibit spectra or fringes lying in every possible direction, or circular ones. As both these results would be equally obtained if the fibres were cut down into particles as long as they are broad, we should have parallel fringes when the particles are arranged in straight lines, and circular ones when the particles are scattered like dust upon a plate of glass in all directions. Hence fibres of minute particles will produce circular fringes, which increase in diameter as the particles are smaller in diameter.

When we therefore look at a candle placed at a little distance, through wool, or cotton, or vapour lying upon glass, or diluted blood or milk, or the seed and farina of plants, &c., we observe round the image of the candle a light area terminating in a *dark reddish* margin. This is followed by a ring of *bluish-green* light, and then a *red* ring, and when the fibres or particles have a uniform size, the green and red rings are frequently repeated. It is to Dr Young that we owe the discovery that the diameter of these rings is always the same when the size of the particles or fibres is uniform and equal, and that they vary inversely as the size

[1] CHROMATICS, § 6.

[2] *Treatise on Light*, § 695. See also Biot, *Traité de Physique*, tom. iv., p. 246.

Periodical Colours.

Dr Young's eriometer.

of the fibres or particles. On this principle he constructed his *Eriometer* for measuring the diameter of minute particles and fibres, such as *wool*, &c. It was composed of a plate of brass, or copper, or even card, with an aperture in the centre about the fortieth of an inch in diameter, and surrounded by a circle of perforations about half an inch in diameter, the number of perforations in the circle being about ten or twelve, and as minute as possible. When the instrument is constructed on such a small scale, the eye requires the aid of a lens. The wool, or plate of particles, is then attached to the end of a slider, and when the light of an Argand lamp, or two or three candles placed in a line, so as to unite their flames, is transmitted through the wool or particles, the slider is drawn out till the first *dark red* coloured circle coincides with the circle of perforations, and the index then shows on the scale upon the slider the number which indicates the size of the fibres or particles. The basis of this scale, rather an imperfect one, Dr Young took from Dr Wollaston's measure of the magnitude of the seeds of the *puff-ball*, or *Lycoperdon bovista*, which he found to be the 8500th of an inch in diameter. Dr Young found the rings formed by these minute seeds to be three and a half on the scale of his instrument, and hence he assumes the *thirty-thousandth* part of an inch (more accurately the 29750th) as the value of a unit on his scale. The following results were obtained by Dr Young:—

Table of the Diameter of Fibres and minute Particles.

Milk, diluted, very indistinct, about	3
Lycoperdon bovista, dust of, very distinct	3½
Blood of a bullock, from beef	4½
Human blood, diluted with water	5
Smut of barley (male ear)	6½
Blood of a mare	6½
Human blood diluted with water after standing five days	6½
Blood recently diluted with serum, only	8
Pus	7½
Silk, very irregular	12
Wool of the beaver, jointed, very uniform	13
Angola wool, about	14
Vigonia wool	15
Siberian hare's wool, Scotch hare's wool, foreign coney wool, yellow rabbit's wool, about	15½
Mole's fur	16
Skate's blood	16
British coney wool, American rabbit's wool, about	16½
Saxon wool, a few fine fibres	17
Buffalo's wool	18
Wool of the mountain sheep (*Ovis montana*)	18
Seal wool, finest, mixed, about	18½
Shawl wool	18 or 19
Goat's wool	19
Cotton, very unequal	19
Peruvian wool, mixed, the finest locks	20
Welsh wool, a small lock of	20
Saxon wool	23 or 24
Wool of an Escurial ram	23 to 24
Southdown wool	24½
Lioneza wool, 24 to 29	generally 25
Paular wool, 24 to 29	generally 25½
Alpaca wool, about	26
Laurèstinus, farina of	26
Ryeland merino wool	27
Merino Southdown wool	28
Lycopodium seed, beautifully distinct	32
Southdown ewe wool	39
Coarse wool, Sussex	46
Coarse wool, from same, worsted	60

The diameter of the fibres or particles in the preceding table may be obtained in parts of an inch by dividing $\frac{1}{30000}$th of an inch by the numbers opposite them. The diameter of the particles of the human blood will be $\frac{1}{30000}$th divided by 5, or the 6000th part of an inch. Dr Young has ingeniously observed, that if we square the number belonging to the pound of wool, and subtract 325, the remainder will be nearly the number of pounds of wool that are worth 100 guineas. In the case of good Lioneza wool, for example, whose number is 25, we shall have $25 \times 25 - 325 = 300$ for 100 guineas, or 7s. per pound.[1]

Periodical Colours.

In experiments of this kind it would be better to express the magnitude of the first ring in parts of the radius, or by the angle which the whole ring subtends at the eye. Those who have any of Mr Barton's scales, with the number of lines in an inch marked, can easily compare the diameter of the first ring produced either by fibres or particles, with the distance of the red spaces in the two first prismatic images; and by the rule of proportion he will find the magnitude of the fibres or particles.

Sect. VIII.—On the Colours of Mixed Plates.

Colours of mixed plates.

Mazeas.

The phenomena of colour observed by M. Mazeas, when he pressed between two glasses, suet, Spanish wax, resin, common wax, and the sediment of urine, are *clearly those of mixed plates*, though they have not hitherto been recognised as such. He put between his glass plates a little ball of suet about one-fourth of a line in diameter, and pressed it between the two surfaces, warming them at the same time in order to disperse the suet. He then rubbed them violently together in a circular manner, and was surprised on looking at a candle through them to see it surrounded with two or three concentric rings, very broad, and with very lively and delicate colours, namely, a red inclining to yellow, and a *green* like that of an emerald. By continuing the friction, the rings assumed the colours of *blue*, *yellow*, and *violet*, especially when he looked through the glasses on bodies directly opposed to the sun.

M. Mazeas[2] shows very clearly that these were not the colours of thin plates, on account of the distance between the glasses, and also because the colours disappeared by melting the suet; but that they were a new species of colours, which he tried in vain to explain.

Dutour.

M. Dutour[3] repeated and varied the experiments of Mazeas, but did not succeed in explaining them.

Dr Young.

Dr Thomas Young, apparently without knowing of the experiments of Mazeas, though they are fully detailed by Priestley, has described the very same colours under the name of the *colours of mixed plates*, and the merit of discovery of these colours has been ascribed to him by almost all modern writers. The method of producing the colours by suet, as given above by Mazeas, is exceedingly simple, while many persons have failed in repeating the experiments described by Dr Young. It is to Dr Young, however, that we owe the higher obligation of having discovered the general principle to which these colours must be referred, though he has not examined the phenomena with that attention which they merited. The following is the account which Dr Young has given of the colours of mixed plates:—

"I first noticed the colours of mixed plates in looking at a candle through two pieces of plate-glass with a little moisture between them. I observed an appearance of fringes resembling the common colours of thin plates; and upon looking for the fringes by reflection, I found that these new fringes were always in the same direction as the other fringes, but many times larger. By examining the glasses with a magnifier, I perceived that wherever these fringes were visible, the moisture was intermixed with portions of

[1] See Dr Young's *Introduction to Medical Literature*, p. 552.

[2] *Mémoires Presentées*, tom. ii., p. 43.

[3] *Mémoires Presentées*, tom. iv., pp. 288, 289; or Priestley *On Vision*, vol. ii., p. 505.

Periodical Colours.

air, producing an appearance similar to dew. I then supposed that the origin of the colours was the same as that of the colours of halos; but on a more minute examination I found that the magnitude of the portions of air and water was by no means uniform, and that the explanation was therefore inadmissible. It was, however, easy to find two portions of light sufficient for the production of these fringes; for the light transmitted through the water, moving in it with a velocity different from that of the light passing through the interstices filled only with air, the two portions would interfere with each other, and produce effects of colour according to the general law. The ratio of the velocities in water and in air is that of 3 to 4; the fringes ought therefore to appear where the thickness is six times as great as that which corresponds to the same colour in the common case of thin plates; and upon making the experiment with a plane glass and a lens slightly convex, I found the sixth dark circle actually of the same diameter as the first in the new fringes. The colours are also very easily produced when butter or tallow is substituted for water, and the rings then become smaller on account of the greater refractive density of the oils; but when water is added, so as to fill up the interstices of the oil, the rings are very much enlarged; for here the difference only of the velocities in water and in oil is to be considered, and this is much smaller than the difference between air and water. It appears to be necessary, for the production of these colours, that the glasses be held nearly in a right line between the eye and the common termination of a dark and luminous object; the portion of the rings seen on the dark ground is then more distinct than the remaining portion; and instead of being continuations of the rings, they exhibit everywhere opposite colours, so as to resemble the colours of common thin plates seen by reflection, and not by transmission. In order to understand this circumstance, we must consider, that where a dark object as A (fig. 145) is placed behind the glasses, the whole of the light which comes to the eye is either refracted through the edges of the drops (as the rays B, C), or reflected from the internal surface (as D, E), while the light which passes through those parts of the glasses which are on the side opposite to the dark object consists of rays refracted as before through the edges (as F, G), or simply passing through the fluid (as H, I). The respective combinations of these portions of light exhibit a series of colours of different orders, since the internal reflection modifies the interference of the rays on the dark side of the object, in the same manner as in the common colours of thin plates seen by reflection. When no dark object is near, both these series of colours are produced at once; and since they are always of an opposite nature at any given thickness of a plate, they neutralize each other, and constitute white light.

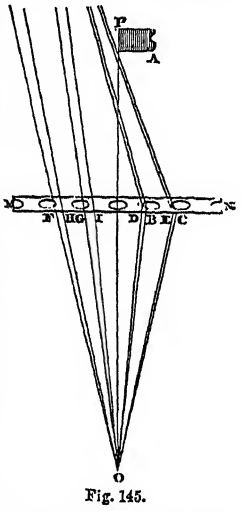


Fig. 145.

"In applying the general law of interference to these colours, as well as to those of thin plates already known, it is impossible to avoid a supposition which is a part of the undulatory theory,—that is, that the velocity of light is the greater the rarer the medium; and there is also a condition annexed to this explanation of the colours of mixed plates, as well as to that of the colours of simple thin plates, which involves another part of the same theory,—that is, that where one of the portions of light has been reflected at the surface of a rarer medium, it must be supposed to be retarded one-half of the appropriate interval; for instance, in the central black spot of a soap-bubble, where the actual lengths of the paths very nearly coincide, but the effect is the same as if one of the portions had been so retarded as to destroy the other. From considering the nature of this circumstance, I ventured to predict that if the two reflections were of the same kind, made at the surfaces of a thin plate of a density intermediate between the densities of the mediums containing it, the effect would be reversed, and the central spot, instead of black, would become white; and I have now the pleasure of stating that I have fully verified this conclusion by interposing a drop of oil of sassafras between a prism of flint-glass and a lens of crown-glass; the central spot seen by reflected light was white, and surrounded by a dark ring. It was, however, necessary to use some force in order to produce a contact sufficiently intimate; and the white spot differed even at last in the same degree, from perfect whiteness, as the black spot usually does from perfect blackness. There are also some irregularities attending the phenomena exhibited in this manner by different refracting substances, especially when the reflection is total, which deserves further investigation."

Periodical Colours.

Later experiments.

We are not aware that these interesting experiments of Mazeas and Dr Young have been repeated by any modern writer, our treatises on optics containing merely an abstract of Dr Young's results. The subject has, however, been taken up by Sir David Brewster, who found that the *colours of mixed plates*, in place of being merely the result of an experiment, was a *natural phenomenon* of a very interesting kind, which frequently presented itself in the examination of minerals. He was therefore led to attach a greater interest to the phenomena which they present.

In order to produce these colours so as to be permanent, he found that the froth of albumen (the white of an egg beat up into froth) ground circularly, as it were, between two thick plates of glass pressed firmly together, when the circular motion is stopped, exhibits the colours very splendidly. The glasses may then be held together by wax or by screws. If we desire to have a circular system of rings, we must use a convex lens in place of one of the plates. Whipped cream answers also very well; but paste that has become very smooth by age he found preferable to any other substance which he employed. When the experiment is successfully made, the colours are extremely splendid, the flame of a candle or other luminous body being of a bright colour complementary to that of the coloured light which surrounds it.

Upon looking with a microscope at the albumen or paste thus pressed into a film, it is found to resemble accurately the strata of cavities containing the new fluids, and sometimes water, as in *sulphate of lime*, &c., the paste being sometimes found in separate ramified patches of all shapes surrounded with air, while on some occasions numerous air-cavities are included in the paste.

Although Dr Young was correct in ascribing the colours of mixed plates to the interference of rays moving with different velocities in passing through the two contiguous media, yet his analysis of the phenomena is imperfect, and his determination of the interfering pencils incorrect. In his 39th lecture he ascribes "the colours seen in the dark part beyond the object to the light scattered irregularly from the surfaces of the fluid;"[1] and in his description of fig. 145 above quoted, he specifies as the interfering portions which produce the colours,—*rays reflected* from the internal surface of the cavities with *rays refracted* through the edges of the drops, and *rays refracted* through the edge with rays *simply passing* through the fluid. That the colours of mixed plates are not produced either by re-

[1] *Elements of Natural Philosophy*, vol. i., p. 470.

Periodical Colours.

fracted or reflected pencils is at once proved by the fact, that the same colours may be produced when the most refracting medium is terminated by a fine edge, and is itself a plate with perfectly parallel surfaces, so that there is no edge to reflect light, and no inclined faces to refract it. Having obtained this result, Sir David Brewster viewed the subject in another aspect, and has shown that the phenomenon is entirely one of inflection caused by the edge of a transparent inflecting body sufficiently thin to produce colours by the interference of the retarded light passing through the body close to its edge, with the light passing without the body close to its edge. The same pencils which interfere in the common case of a diffracting body interfere in the present case; but the pencils that pass through the transparent plate are modified by the retardation which they experience, so as to produce the phenomena of colours. The oppositely coloured pencils in mixed plates form part of the system of diffracted fringes, the colour seen upon the luminous body occupying the shadow of the diffracting edge, and the opposite colour seen around or beside the candle occupying the first fringe on each side of the shadow. The colours in the fringe on the left hand of the shadow of the diffracting edge are seen by the eye on the right hand side of the candle, and those in the fringe on the right hand of the shadow are seen by the eye on the left hand side of the candle.

All the preceding phenomena may be produced by breaking down a thin transparent plate into minute portions, and making these portions to float in a fluid, or placing them between two plates of glass containing a fluid of nearly the same refractive power as the solid portions. The solid portions will thus act like much thinner plates placed in air, and we shall observe the identical phenomena which take place with the cavities in paste or albumen. When we examine with the microscope a very narrow portion of the solid substance bounded by lines nearly parallel, we perceive the phenomena of mixed plates under a new aspect. The space between the shadow of the two edges is filled up with a bright band of the colour which occupies the two first external fringes; and as the innermost fringe of each edge overlap each other, the colour has double the intensity. The same phenomenon is often seen in the parallel ramifications, or in the long cavities produced by the paste or albumen, when the last act of friction was to move one of the plates of glass in a straight line.

The phenomena of mixed plates have been discovered by Sir David Brewster in *sulphate of lime*, in which there are shallow crystallized cavities in great numbers, forming regular strata in the mineral. These cavities are filled with water, and in this case the diffracting edge is the edge of the cavity, and the light which passes through the water has its velocity greater than that which passes through the solid mineral.

In one remarkable circular stratum of cavities, all the cavities in the centre were the deepest, and gradually diminished in depth towards the circumference, till the microscope could scarcely resolve them. The highest orders of colours were therefore in the middle of the stratum, and they gradually descended to a white of the first order, at the circumference of the circular stratum.[1]

An interesting experiment, published by Fox Talbot, Esq.,[2] is a phenomenon of mixed plates, in which the densest of the plates is too thick to produce the colours at its edge in common light. "Make," says he, "a circular hole in a piece of card of the size of the pupil of the eye. Cover one-half of this opening with an extremely thin film of glass (probably mica would answer the purpose as well, or better). Then view through this aperture a perfect spectrum formed by a prism of moderate dispersive power, and the spectrum will appear covered throughout its length with parallel obscure bands resembling the absorptions produced by iodine vapour. The cause of this phenomenon probably is, that one-half of the light which passes through the glass film has its undulations thereby retarded by a certain quantity."

Double Refraction.

This phenomenon, which we have observed under various modifications, arises from the diffraction of the light passing on each side of and very close to the edge of the film; for if we cover this edge even with a fine wire, we obstruct the diffracted fringes modified by the retardation of the denser plate, and the phenomenon vanishes. Hence, in order to see the fringes in perfection, we must make the aperture no wider than to include the space on each side of the edge of the film within which the light passes that is concerned in the phenomenon. As the light here used is perfectly homogeneous, the bands are alternately coloured and obscure.

Sir David Brewster has observed the fringes described by Mr Talbot with thick plates having fine edges, and immersed in fluids, and even with plates of glass the fifteenth part of an inch thick, by looking through their edge upon a highly-dispersed spectrum formed by a large refracting angle of a prism, and magnified by a powerful telescope. The perfection of the edge of the film, and an equality of thickness, are essential to the production of the fringes in their most interesting form. Sir David Brewster obtained them by looking through plates of sulphate of lime, where there were not properly speaking plates of different refractive powers, but where the plate suddenly became thicker, as shown in the annexed figure, where AB, FC is the plate of sulphate of lime, which becomes thicker at F. When the eye looks through it at the spectrum in the direction FD, it sees the fringes, which have the same magnitude as if the plate ADB were removed, and the eye looked only through the plate CF, in which case it is clearly a phenomenon of mixed plates.

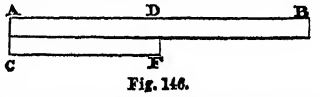


Fig. 146.

When these dark lines were produced in great perfection, they had a sort of granular structure resembling fine screws at their edges, and sometimes appearing to inclose minute specks of light. Several other remarkable phenomena accompanying these fringes were communicated by the author to the British Association at Liverpool. This interesting experiment has been the subject of several communications to the British Association by Sir David Brewster, and of two papers by Mr Airy, and one by Professor Stokes, in the *Philosophical Transactions*.

Part VI.—ON THE DOUBLE REFRACTION OF LIGHT.

Double refraction.

In the preceding part of this article we have supposed that when light is transmitted vertically through the surfaces or through the mass of transparent bodies, or when it passes obliquely and is refracted by the same bodies, it leaves the surface or emerges from the body in a single pencil, either perfectly white, or decomposed into a diverging beam of coloured light. This supposition is perfectly correct, under certain circumstances, for gaseous and fluid bodies, for glass slowly and equally cooled, and for a numerous class of crystallized bodies, whose primitive form is either the *cube*, the *regular octohedron*, or the *rhomboidal dodecahedron*. When these bodies have the same temperature and density throughout their mass, and are not exposed to any pressure, a pencil of light will be transmitted through them *single*, according to the laws already explained.

[1] See *Phil. Trans.* 1837, p. 73.

[2] *Lond. and Edin. Phil. Mag.*, May 1837, p. 364.

Double Refraction.

When a pencil of light falls upon all other bodies, such as artificial crystals, or salts or crystallized minerals, which have not the above primitive forms; upon animal substances, such as bone, horn, shell, hair, crystalline lenses of animal and elastic integuments; upon vegetable bodies, such as particular leaves, stalks, and seeds; upon artificial bodies, such as gums, resins, jellies, and solid bodies that have a variable density, during the transient passage of heat, or from rapid cooling, or unequal temperature and pressure:—when a pencil of light falls upon such bodies, it will be refracted into two distinct pencils, more or less inclined to each other according to the mechanical condition of the body, or to the direction in which the pencil passes through it. In some minerals and artificial crystals this refraction of the two pencils is very great, and, generally speaking, is in such crystals easily observed and measured; but in some cases it is not visible unless by transmitting the light through prisms of the body with large refracting angles; and in very many cases, the existence of two pencils is inferred only from certain other properties, which always accompany the property of giving double pencils. This separation of a single pencil into two is called *double refraction*, and the bodies which have such a property are called *doubly-refracting crystals* or *bodies*.

In many regular crystals there is *one line* through which, if a single pencil of light is transmitted, it does not experience double refraction. This line is called the *axis of the crystal*, or the *axis of double refraction*, and such crystals are denominated crystals with one axis of double refraction. In other crystals there are two lines through which, if the single pencil of light is transmitted, it does not experience double refraction. Such crystals are denominated crystals with two axes of double refraction. We shall treat of these two classes in separate sections.

Sect. I.—On the Law of Double Refraction in Crystals with One Axis.

Bartholinus discovered the property of double refraction in the mineral called *Iceland spar*, *calcareous spar*, or by chemists, *carbonate of lime*; and it is well fitted for exhibiting the phenomena, owing to its perfect transparency, and the great separation of the two pencils. This mineral consists, according to Stromeyer, of 56·15 parts of lime, and 43·7 of carbonic acid. It crystallizes in the form of an obtuse rhombohedron, as shown in fig. 147, where ABCB′, AB′C′B″, &c., are the faces of the rhombohedron, and AA′ the axis of the rhombohedron, or the line joining its two obtuse angles. The following are the dimensions of the crystal, as given by Malus, who observes that the first angle, from which all the rest are derived, is within *ten seconds* of the truth.

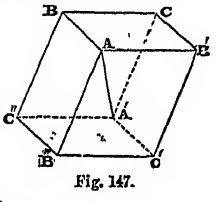


Fig. 147.

Inclination of the faces ABCB′, AB′C′B″	105°	5′	0″
Inclination of the faces ABCB′, A′CBC″	74	55	0
Plane angle between the edges AB, AB′	101	55	0
,, ,, ,, AB, BC	78	4	59
Inclination of the faces to the axis AA′	45	23	26
Angle between the edges AB, AB′, &c., and the axis AA′	66	44	45
Inclination of the edges AB, AB′ to the opposite faces AB′C′B″, &c.	109	8	12
,, ,, A′C, A′C″ to the opposite faces A′CBC″, &c.	70	51	48
Length of the diagonal AA′, the sides AB, AB′ being unity	1·2598		

As Iceland spar cleaves equally in planes parallel to all its six faces, it is easy to cut out of any mass of it an accurate rhombohedron in which all the three sides AB, AB′, AB″, are equal; but for the purposes of experiment it is sufficient to have a piece with two smooth and parallel faces formed by cleavage, or ground and polished parallel to the cleavage planes. Double Refraction

Let AX (fig. 148) be such a piece of Iceland spar, and ABDC its upper surface. If we place its lower surface upon a piece of paper having a black line MN drawn upon it, and if we place the eye above the upper surface, we shall see the line MN distinctly doubled; or if it should appear single, the two images will separate by turning the spar a little round, and the line will appear double as at MN and *mn*. The one line will be found to coincide with the other when MN is parallel to AD, the short diagonal of the rhomboidal face ABDC, and the lines will appear most separated when MN is parallel, as in the figure, to the long diagonal BC. If a black spot placed at O is used in place of a line, it will appear double in every position; and in turning the crystal round, the other image E will seem to revolve round O.

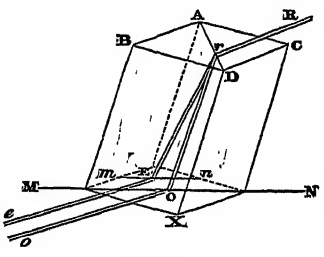


Fig. 148.

The best way, however, of showing the double refraction of the Iceland spar is to make a ray of light R*r* fall upon the crystal at *r*. This ray will be refracted into two pencils or rays *r*O, *r*E, and these will be again refracted at the second surface of the spar in directions E*e*, O*o*, parallel to the original ray R*r*. If we measure the angles of refraction of the fixed ray O*o*, corresponding to several angles of incidence from 0° to 90°, we shall find that these angles are always to one another in the constant ratio of 1 to 1·654, and that the refracted ray *r*O is always in the plane of incidence. It follows, therefore, that this ray is refracted, as in water and glass, according to the ordinary law of refraction discovered by Snellius. Hence it is called the *ordinary ray*. But if we make the same experiments on the other ray *r*E, we shall find that at an incidence of 0°, in place of passing on unrefracted, it is actually refracted 6° 12′; that at other incidences its angles of refraction are not regulated by the law of Snellius, and that the ray *r*E is not in the plane of incidence. We conclude, therefore, that the ray *r*E is refracted according to some new or extraordinary law which remains to be investigated; and hence the ray *r*E is called the *extraordinary ray*.

If we grind down the two solid obtuse angles A, A′ (fig. 147) so that the ground surfaces are perpendicular to the axis AA′, and if we polish their surfaces, and transmit a ray perpendicularly through them, so as to be parallel to the axis AA, we shall find that there is only one refracted ray; and hence there is no double refraction along the axis. Now this line AA′ is not a *fixed axis* like that of the earth; it is merely a *fixed direction*, for every line parallel to AA′ enjoys the property of an axis, as there is no double refraction in lines parallel to AA′.

In order to obtain an accurate idea of the law of extraordinary refraction, or that by which the extraordinary ray *r*E is regulated, let us take a rhomb, such as that shown in fig. 147, and grind it into an accurate sphere, and then polish it. Let ACBD (fig. 149) be such a sphere, AB being its axis of double refraction, corresponding with AA′ in fig. 147, and let O be its centre. If we now bend a piece of sheet-lead or sheet-copper into an arch ADB, and making a small hole in it opposite to A, and another opposite to B, cement a handle to it about D, it will enable us, in the following manner, to detect the general law of extraordinary refraction. The use of the two holes in this

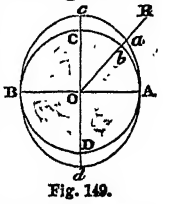


Fig. 149.

Double Refraction.

experiment is to insure that the light admitted through one of them, and emerging at the other, shall pass through the centre O of the sphere. Let one of the holes be now placed in the surface of the sphere at A, and the eye at the other hole at B, the hole will appear single, showing that the double refraction is there nothing. Let the hole be shifted gradually from A to C, and the other hole will move from B to D. In the different positions from A to C, it will be seen that the hole begins to become double on leaving A, and that the distance of the two images of it gradually increases from A to C, where it becomes a maximum. The same result will be obtained by making the hole move from A to D, or in any quadrant of the sphere passing through the holes A and B. The very same result will be obtained if the hole moves from B to C, or from B to D. If we now make one of the holes move along the equator COD, we shall find that by placing the eye at the other hole, the distance of the images will be exactly the same, or the double refraction the same in every part of the equator. Hence the general law of double refraction in crystals with one axis is a very simple one: it is nothing at the poles; it increases gradually from the poles to the equator, where it is a maximum; it is the same in the same parallels of latitude; and the preceding experiments will also show that the line joining the centres of the two images is in the plane of the meridian.

Let the index of extraordinary refraction be now measured at the pole A, where it is the same as the ordinary index, and at the equator C, and it will be found to be 1·654, or m, in the former case, and 1·488, or m', in the latter. Now Huygens was led, by a theory which has been explained under CHROMATICS, to the following law, which he verified by experiment, and which has been confirmed by the experiments of Wollaston, Malus, and other philosophers. Upon the axis AB of the sphere (fig. 149) describe an ellipse AcBd, whose lesser axis AB is to its greater axis cd as $\frac{1}{m}$ is to $\frac{1}{m'}$, or as $\frac{1}{1\cdot654}$ is to $\frac{1}{1\cdot488}$, or as ·604 to ·674; and if an oblate spheroid is supposed to be generated by the revolution of this ellipse round its lesser axis AB, the reciprocal of the index of refraction of the extraordinary ray at any point of the spheroid will be measured by its radius at that point; that is, if RabO is a ray incident at b, the radius $\frac{1}{Oa}$ will be the extraordinary index of refraction for that ray. If we therefore make

φ = ROA, or the inclination of the incident ray to the axis,
R = cd, the major axis of the spheroid,
r = AB, the lesser axis;

then it may be shown, as Malus has done,[1] that

$$Oa = \frac{Rr}{\sqrt{(r^2 \sin^2\varphi + R^2\cos^2\varphi)}};$$

and as the index of refraction of the extraordinary ray is the reciprocal of this radius, we have

$$m' = \frac{\sqrt{(r^2\sin^2\varphi + R^2\cos^2\varphi)}}{Rr}; \text{ or}$$

$$m'^2 = \frac{1}{r^2} - \left(\frac{R^2 - r^2}{R^2 r^2}\right)\sin^2\varphi.$$

In the case of Iceland spar, we have

$$m'^2 = 2\cdot736693 - 0\cdot536510\sin^2\varphi; \text{ or}$$

$$m' = \sqrt{2\cdot736693 - 0\cdot536510\sin^2\varphi}.$$

As the index of extraordinary refraction thus found is always equal to the index of the ordinary refraction, *minus* another quantity which depends on the difference between the radius of the sphere and that of the spheroid, the crystals in which this happens may be called *negative* doubly-refracting crystals.

Double Refraction.

The preceding law of double refraction was believed by Malus to be universal, and applicable to all crystals that had this property. M. Biot, however, discovered that in quartz or rock-crystal the extraordinary ray had its index of refraction m' greater than the ordinary index m. This mineral crystallizes in six-sided prisms, as shown in the annexed figure, terminated by six-sided pyramids, A and B. If we grind down and polish the summits A and B of a large crystal, perpendicular to the axis AB, and if we determine the index of refraction when the rays pass along AB, we shall find it to be as Malus found it, 1·5484, and without any double refraction, and 1·5544 in a direction perpendicular to the axis.

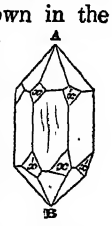


Fig. 150.

If we now grind the crystal into a sphere ACBD (fig. 151), and if we perform the very same experiments with it as we did with Iceland spar, we shall obtain analogous results. The double refraction will be found to increase from the poles A, B to the equator CD, and to be the same in every part of the equator, and in each parallel of latitude; the only differences between it and calcareous spar being, that the double refraction is less, and that the index of refraction of the extraordinary ray is always *greater* than that of the ordinary ray.

The extraordinary refraction of quartz will, therefore, as M. Biot has shown, be represented by a prolate spheroid generated by the revolution of the ellipse AcBd, whose greater axis AB is to the lesser cd as $\frac{1}{1\cdot5484}$ is to $\frac{1}{1\cdot5544}$, or as ·6458 is to ·6418. Hence, if RbaO is a ray incident on the sphere at b, the radius $\frac{1}{Oa}$ will be the index of extraordinary refraction for that ray. Hence we shall obtain $Oa = \frac{Rr}{\sqrt{(r^2\sin^2\varphi - R^2\cos^2\varphi)}}$, and

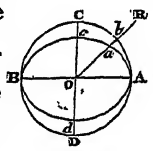


Fig. 151.

$$m^2 = \frac{1}{r^2} + \left(\frac{R^2 - r^2}{R^2 r^2}\right)\sin^2\varphi.$$

As the index of extraordinary refraction, therefore, is equal to the index of ordinary refraction, *plus* another quantity depending on the difference between the radius of the sphere and that of the prolate spheroid, crystals which have this property may be called *positive* doubly-refracting crystals.

The following geometrical rule for finding the direction of the extraordinary ray, when the incident ray forms different angles with the axis, given by Huygens,[2] may be interesting to some of our readers.

Let CGHF (fig. 152) be what is called the *principal section* of a crystal of calcareous spar, &c., or a plane passing through the axis, which will be in the direction CH. Let SK, VK be rays incident on that plane upon the surface CG, and equally inclined to IKL, perpendicular to the surface at the point of incidence K; then if KM is the refracted ray corresponding to a ray IK incident perpendicularly, the other rays VK, SK will be refracted in directions KT, KX, so that TM is equal to XM.

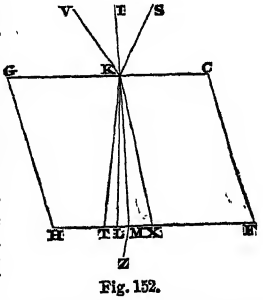


Fig. 152.

Although the determination of the extraordinarily refracted ray is very simple, when the crystal is supposed to

[1] *Theorie de la Double Refraction*, p. 143.

[2] *Traité de la Lumière*, sect. 17.

Double Refraction.

be spherical, yet the formula becomes complicated when we suppose the ray incident in any given direction upon a natural surface of Iceland spar. Malus has investigated such a formula, but our limits will not allow us to give more than the resulting expression.

Making θ = the angle of incidence,
θ' = the angle of extraordinary refraction,
π = the azimuth of incidence, or the angle which the plane of incidence forms with the axis,
π' = the same angle for the extraordinary ray,
λ = the inclination of a line perpendicular to the face of incidence to the axis of the crystal,
$A = R^2 \sin^2\lambda + r^2\cos^2$,
$C = \sin\lambda\cos\lambda\,(R^2 - r^2)$. Then

$$\tan\theta,\ \cos\pi' = \frac{R^2 r^2 \sin\theta\cos\pi}{A\sqrt{A - R^2\sin^2\theta(r^2\cos^2\pi + A\sin^2\pi)}} + \frac{C}{A}$$

$$\text{and } \tan\theta'\sin\pi' = \frac{R^2\sin\theta\sin\pi}{\sqrt{A - R^2\sin^2\theta\,(r^2\cos^2\pi + A\sin^2\pi)}}.$$

When the refracting surface is parallel to the axis (as in the six-sided prism of calcareous spar), we shall have $\lambda = 90$, in which case $A = r^2$ and $C = 0$. The formula then becomes

$$\tan\theta'\cos\pi = \frac{r^2\sin\theta\cos\pi}{R\sqrt{1 - \sin^2\theta\,(r^2\cos^2\pi + R^2\sin^2\pi)}}$$

$$\tan\theta'\sin\pi = \frac{R\sin\theta\sin\pi}{\sqrt{1 - \sin^2\theta\,(r^2\cos^2\pi + R^2\sin^2\pi)}};$$

and dividing the one equation by the other, we have

$$\tan\pi' = \frac{R^2}{r^2}\tan\pi.$$

When the refracting surface is parallel to the axis, and the plane of incidence perpendicular to the axis, then $\pi = \pi' = 90°$, or $\lambda = 90$; consequently $\cos\pi' = 0$, and the first equation becomes

$$\tan\theta' = \frac{R\sin\theta}{\sqrt{1 - R^2\sin^2\theta}}, \text{ and } \sin\theta' = R\sin\theta.$$

When the refracting surface is parallel to the axis, and the plane of incidence passes through the axis, in which case the refraction is in the plane of a *principal section*, then $\pi = \pi' = 0°$, the second equation becomes

$$\tan\theta' = \frac{r}{R} + \frac{r\sin\theta}{\sqrt{1 - r^2\sin^2\theta}},$$

or, by substituting $r\sin\theta$ for its equal $\sin\theta$, we have

$$\tan\theta' = \frac{r\sin\theta}{\sqrt{1 - r^2\sin^2\theta}},$$

which substituted in the general formula, gives

$$\tan\theta' = \frac{2}{R}\tan\theta.$$

When the refracting surface is perpendicular to the axis of the crystal, as in the chaux carbonatée basée of Hauy, then $\lambda = 0°$, and $A = r^2$, and $C = 0$. Hence

$$\tan\theta'\sin\pi' = \frac{R^2\sin\theta\sin\pi}{r\sqrt{1 - R^2\sin^2\theta}},$$

$$\tan\theta\cos\pi' = \frac{R^2\sin\theta\cos\pi}{r\sqrt{1 - R^2\sin^2\theta}};$$

and dividing the one equation by the other, we have

$$\tan\pi' = \tan\pi, \text{ and } \pi' = \pi,$$

which shows that the refracted ray is in the plane of the incident ray. Hence we obtain from the preceding equation

$$\tan\theta = \frac{R^2\sin\theta}{r\sqrt{1 - r^2\sin^2\theta}}.$$

In order to find the path of the extraordinarily refracted ray, Huygens has given the following elegant geometrical construction. Let EBH (fig. 153) be the elliptical section of the oblate spheroid which regulates the double refraction of the crystal, formed by the surface upon which the ray is incident. Let the ray RC fall upon its centre, and let BCK be the intersection of the plane of incidence with the face of the crystal. Let EMH be a part of the oblate spheroid within the crystal or below its surface, the axis of the spheroid passing through and having any inclination to the surface. Then draw in the plane KCR a line CO perpendicular to RC, and having drawn OK perpendicular to OC, or parallel to CR, make OK equal to $\frac{1}{3m \text{ incid.}}$, or the reciprocal of the sine of the angle of incidence. Through K draw KT perpendicular to the plane of incidence BRCK, and through KT draw a plane which shall touch the spheroid. Let I be the point where this plane touches the spheroid, then drawing the line CI, this line will be the extraordinarily refracted ray.

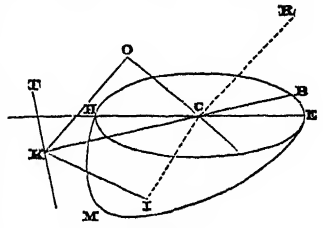


Fig. 153.

Double Refraction.

As there are several researches and instruments in which it may be required to find the focus of the extraordinary pencil when the doubly-refracting substance has the form of a lens, we shall here give the formula obtained by Malus.

Doubly-refracting lenses.

Calling r, r' = radii of the anterior and posterior surfaces of a convex lens,
d = distance of the radiant point,
a = larger semi-axis of the spheroid of double refraction,
b = shorter semi-axis of ditto,
F = focal length for the ordinary ray,
f = focal length of the extraordinary ray, when d is infinite, or the rays parallel, and
φ = focal length of the extraordinary ray required.

Then Malus has shown that

$$\varphi = -\frac{a^2 b d r r'}{d(r + r')\,(2b^2 - a^2 - a^2 b) - a^2 b r r'};$$

$$F = \frac{-brr'}{(r + r')\,(1 - b)},$$

When the radii r, r' are equal, or the lens *equally convex*, we have

$$\varphi = -\frac{a^2 b d r}{2d(2b^2 - a^2 - a^2 b) - a^2 b r},$$

$$f = -\frac{a^2 b r}{2(2b^2 - a^2 - a^2 b)}.$$

If we suppose a to be equal to b, or the spheroid to become a sphere, by which the ordinary refraction is regulated, we obtain for the ordinary ray

$$F = \frac{br}{2(1 - b)}.$$

Hence the difference between the ordinary and extraordinary focal lengths will be

$$f - F = 2F\frac{a^2 - b^2}{2b^2 - a^2 - a^2 b}.$$

If we change the signs of r and r' in these expressions, they will apply to *concave* lenses.

Lenses of Iceland spar.

If we now take *Iceland spar*, and suppose the lens to be formed of that substance, we have only to substitute in the preceding equation the following values of a and b,[1] viz.:—

$a = 0{\cdot}6741717$ whence $m = 1{\cdot}65429$
$b = 0{\cdot}6044871$; whence $m' = 1{\cdot}48330$,

we obtain

$\varphi = -r\,.\,8{\cdot}8228602$ $\quad f - F = -F\,.\,114{\cdot}4546$
$F = -r\,.\,0{\cdot}764180$

[1] Malus, *Theorie*, &c., p. 278, sect. 66.

Double Refraction.

In the case of *quartz* or *rock crystal*, where

$a = 0{\cdot}645813$ $\quad m = 1{\cdot}558176$
$b = 0{\cdot}641776$ $\quad n = 1{\cdot}548435$

we obtain

$\varphi = -r\,.\,0{\cdot}962824$ $\quad f - \mathrm{F} = -\mathrm{F}\,.\,0{\cdot}074846$
$\mathrm{F} = -r\,.\,0{\cdot}895775$

In all lenses of the same substance, the ratio of f to F will be constant, whatever be the form of the lenses, provided the incident rays are parallel. If, in the general expression of φ, we make d infinite, we have

$$\varphi = \frac{a^2 brr'}{(r+r')\,2b^2 - a^2 - a^2 b};$$

and making $a = 0$, we have for the ordinary ray,

$$\mathrm{F} = -\frac{brr'}{(r+r')(1-b)}, \text{ whence } \frac{\varphi}{\mathrm{F}} = \frac{a^2(1-b)}{2b^2 - a^2 - a^2 b};$$

a result independent of the values of r and r'.[1]

The focus of the rays refracted extraordinarily by a doubly-refracting lens, becomes more and more distant, as the axis of double refraction of the crystal approaches to the axis of the lens; and the preceding formulæ apply solely to the case where these two axes are parallel, as it is only in that case that such lenses can be of any use.

List of the Primitive Forms and Crystals which have one axis of Double Refraction.

Crystals with one axis.

From a very extensive series of experiments on the double refraction of crystallized bodies, Sir David Brewster was led to the general law, that all crystals whose primitive form has only *one axis* of figure, or one pre-eminent line, round which the matter of the crystals is symmetrically arranged, had also *one axis* of double refraction, and that their axis of figure was likewise the axis of double refraction.

The following are the primitive forms which possess this geometrical and optical property:—

The rhombohedron with an obtuse summit.
The rhombohedron with an acute summit.
The regular six-sided prism.
The octohedron with a square base.
The right prism with a square base.

Table of Crystallized Minerals and other bodies which have one axis of Double Refraction.[2]

In the following table the crystals are arranged under their primitive forms, so far as these forms have been determined by crystallographers. The sign + indicates that the crystals have *positive* double refraction, like *quartz*, and − that they have *negative* double refraction, like *Iceland spar*.

1. *Rhombohedron with an Obtuse Summit.* (Fig. 154)

− Phakolite, Dx.
− Nitrate of lithine, Dx.
− Carbonate of lime (Iceland spar).
− Carbonate of lime and iron.
− Carbonate of lime and magnesia.
− Phosphato-arseniate of lead.
− Carbonate of zinc.
− Nitrate of soda.
− Phosphate of lead.
− Ruby silver.
− Levyne.
− Tourmaline.
− Rubellite.
− Aulunite.
− Gmelinite.
− Chlorate of soda.
+ Dioptase.
+ Chabasie Andreasberg, Dx.
+ Succinate of lithine, Dx.

2. *Rhombohedron with Acute Summit.* (Fig. 155.)

− Corundum.
− Sapphire.
− Ruby.
− Arseniate of copper.
− Suzannite, Dx.
+ Cinnabar.
+ Eudyalite, Dx.
+ Pennine D'Ala, Dx.

3. *Regular Six-sided Prism.* (Fig. 156.)

− Ioduret of lead.
− „ of cadmium, Dx.
− Emerald.
− Arseniate of lead.
− Beryl.
− Apatite.
− Muriate of lime.
− „ of strontian.
− Eukolite, Dx.
− Pyrosmalite, Dx.
− Iodoform, S.
− Ruby silver.
− Hyposulphite of lime, B. S.
− „ of strontian, S.
− Sulphate of glucine, S.
− Nepheline.
+ Hydrate of magnesia (Brucite).
+ Quartz.
+ Amethyst.
+ Willemite, Dx.
+ Leuchtenbergite, ? Dx.
+ Parisite, Dx.
+ Greenockite, Miller.
+ Sulphate of potash, S.
+ Hyposulphate of lead, S.
+ Oxide of zinc, sublimed, Dx.
+ Spartalite, Dx.
+ Ioduret of silver, Dx.
+ Phenakite.

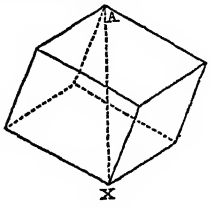


Fig. 154.

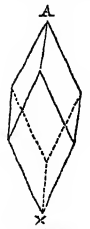


Fig. 155.

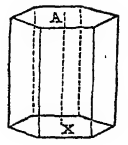


Fig. 156.

4. *Octohedron with a Square Base.* (Fig. 157.)

− Mellite.
− Molybdate of lead.
− Octohedrite.
− Muriate of potash.
− Cyanide of mercury.
+ Zircon.
+ Oxide of tin.
+ Tungstate of lime.
+ Metatungstate acid of ammonia, Dx.

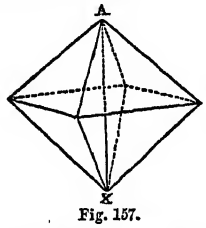


Fig. 157.

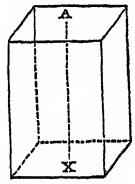


Fig. 158.

5. *Right Prism with a Square Base.* (Fig. 158.)

− Idiocrase.
− Wernerite.
− Paranthine or scapolite.
− Meoinite.
− Somervillite.
− Edingtonite.
− Arseniate of potash.
− Matlockite.
− Arseniate of ammonia.
− Sulphate of copper & ammonia.
− Subphosphate of potash.
− Phosphate of ammonia and magnesia.
− Sulphate of nickel.
− Sulphate of nickel and copper.
− Hydrate of strontites.
− Chiolite, Dx.
− Gehlenite.
− Dipyre, Dx.
− Mellilite, Dx.
− Apophyllite of Cziclowa.
− Chalcolite, Dx.
− Pennine from Zermat, Dx.
− Melinophane, Dx.
− Clintonite, Dx.
− Red ioduret of mercury.
+ Apophyllite of Uton.
+ Oxahverite.
+ Superacetate of copper and lime.
+ Titanite.
+ Ice, certain crystals. Murio-carbonate of lead.
+ Calomel, S.
+ Phosgenite, Dx.
+ Rutile.
+ Hydrofluate of the fluorine of potassium, Dx.
+ Cyanuret of magnesium and platinum, Dx.
+ Prussiate of potash, yellow.
+ Urea, Dx.
+ Sarcolite, Dx.

The following crystals and organized bodies have one axis of double refraction, but their primitive form has not been accurately determined.

	Position of the axis.
− Xanthophilite, Dx.	
− Brandisite.	
− Mica from various localities.	Perpendicular to laminæ.
− Mica, with amianthus.	Perpendicular to laminæ.
− Nacrite (See *Phil. Trans.*, 1836).	Perpendicular to laminæ.
+ Boracite.	Axis of rhomb of 90°.
+ Apophyllite (*surcomposée* of Hauy)	Perpendicular to the table.
+ Sulphate of potash and iron.	Axis of six-sided prism.
+ Kalapleite, Dx.	Axis of hexagonal plates.
+ Chlorite, white, Dx.	Do.
Tortoise-shell (Sir J. Herschel)	

[1] Malus, *Theorie*, &c., p. 278, § 66.

[2] In this Table the crystals marked Dx. were observed by M. A. Descloiseaux (see *Ann. des Mines*, vol. xi., p. 261); and those marked S. by M. Senarmont (see *Ann. de Chim. et de Phys*, 3d series, tom xxxiii.)

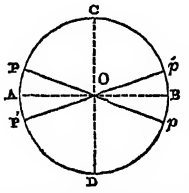
Double Refraction.

Sect. II.—On the Law of Double Refraction in Crystals with Two Axes.

When M. Malus published his theory of double refraction, and even so late as 1816, all crystals were believed to have only one *axis* of double refraction, one of the rays being refracted by the ordinary law, and the other by the extraordinary law, above explained. During the examination of an extensive class of minerals and artificial salts, Sir David Brewster was led to the discovery of crystals with *two axes of double refraction.*

The general character of the phenomena presented by such crystals will be understood from fig. 159, where we may suppose, as before, the crystal to have the form of a sphere. In place of there being one line along which there is no double refraction, there are two such as P*O*p, P′*O*p′, in which the incident pencil is not divided into two. The double refraction increases on each side of these axes, from P, to C and A, and from P′ to D and A. The double refraction increases in the very same manner from *p* to C and B, and from *p′* to D and B, according to a law which will afterwards be explained.

Fig. 159.



In continuing his investigations, Sir David Brewster found crystals in which the axes P*O*p, P′*O*p′ formed all possible angles with each other from 0° up to 90°, and he was led also to the important result, that these two axes were not real axes of double refraction like those in uniaxal crystals, but were only *resultant axes*, as he called them, or *axes of compensation.* The grounds on which he formed this opinion were, that these lines P*O*p, P′*O*p′ had no relation whatever to any fixed or permanent lines in the primitive form of the crystals, like the axes of uniaxal crystals, and that the double refraction did not altogether vanish along these lines, as in Iceland spar and other minerals with no axis. He was led to these results, not by measuring the double refraction itself, but by the phenomena which will be presently explained. At this time it was the opinion of our author, and afterwards that of M. Biot and other distinguished philosophers, that in *biaxal* as in uniaxal crystals, one of the rays was refracted according to the ordinary law of Snellius, and the other according to an extraordinary law, and hence the investigation of the extraordinary law occupied the attention of our author.

In commencing this inquiry, he assumed as the two real axes of double refraction, the line AB bisecting the angle formed by the apparent or resultant axes P*O*p, P′*O*p′, and another line at right angles to it, viz. either the line CD, or the line perpendicular to it passing through O.

If the principal axis AB is *positive*, then if we assume O as the second axis, it must be taken *positive* also; but if CD is assumed as the second axis, it must be taken *negative.* Now, it is obvious that if we take AB as a *positive*, and CD as a *negative* axis, the double refraction in the direction AB is the maximum double refraction of the axis CD, because the effect of the axis AB is here nothing. In like manner, the double refraction along CD is a measure of the maximum double refraction of the axis AB. Hence we can easily ascertain the relative intensities of the doubly refracting force of each axis AB and CD. Having done this, the next step was to compute the double refraction at the point P produced by the positive axis AB acting alone as a single axis, and also the double refraction produced at the same point P, by the negative axis CD. When this was done, the two double refractions were found to be equal and opposite, and hence they compensated each other, and produced an axis P*p*, in which there was no double refraction, and which was the resultant of the actions of AB and CD.

In this way, and by experiments which will be related in a subsequent chapter, our author was led to the following method of finding the general law of extraordinary refraction in biaxal crystals. Double Refraction.

Make b = axis of revolution of the two spheroids.
a, a' = the other axis of the spheroid.
β, β' = the inclination of the incident ray to the axes of the crystal.
ψ = the angle of the doubly refracting forces emanating from each axis.
ζ = half the difference of the angle at the base of the parallelogram of forces.

Then, as the velocity of the ray is inversely as the variable radius of the spheroid, $\frac{1}{b^2}$ will be the square of the velocity of the ordinary ray, and $\frac{1}{a^2}$, $\frac{1}{a'^2}$ the square of the minimum velocity of the extraordinary ray, in virtue of the separate action of each axis, AB and CD. Hence the difference between the squares of the velocities of the ordinary and extraordinary rays will be

$$\left(\frac{a^2 \pm b^2}{a^2 b^2}\right) \sin.^2 \beta$$

$$\left(\frac{a'^2 \pm b^2}{a'^2 b^2}\right) \sin.^2 \beta$$

the sign being positive when the axis is positive, and ***vice versa.*** But as these expressions represent the sides of the parallelogram of forces, we have

$$\text{Tang. } \zeta = \frac{\left(\frac{a^2 \pm b^2}{a^2 b^2} \sin.^2 \beta\right) - \left(\frac{a'^2 \pm b^2}{a'^2 b^2} \sin.^2 \beta'\right) \text{tang. } \frac{1}{2}\psi}{\frac{a^2 \pm b^2}{a^2 b^2} \sin.^2 \beta + \frac{a' \pm b^2}{a'^2 b^2} \sin.^2 \beta'.}$$

Consequently the difference between the squares of the velocities of the ordinary and extraordinary ray produced by the combined action of the two axes, will be

$$\frac{\left(\frac{a^2 \pm b^2}{a^2 b^2} \sin.^2 \beta\right)(\sin. \psi)}{\sin. (\zeta + \frac{1}{2}\psi).}$$

Hence, calling V the velocity required, we have

$$V^2 = \frac{1}{b^2} \pm \frac{\left(\frac{a^2 \pm b^2}{a^2 b^2} \sin.^2 \beta\right)(\sin. \psi)}{\sin. (\zeta + \frac{1}{2}\psi)}, \text{ and}$$

$$V = \left\{ \frac{1}{b^2} + \frac{\left(\frac{a^2 \pm b^2}{a^2 b^2} \sin.^2 \beta\right)(\sin. \psi)}{\sin. (\zeta + \frac{1}{2}\psi)} \right\}^{\frac{1}{2}}$$

The form of the compound, or irregular spheroid, may therefore be computed for all doubly refracting crystals.

The general law of extraordinary refraction which has now been explained, may be thus expressed.

The increment of the square of the velocity of the extraordinary ray produced by the action of two axes of double refraction, is equal to the diagonal of a parallelogram whose sides are the increments of the square of the velocity produced by each axis separately, and calculated by the law of Huygens, and whose angle is double of the angle formed by the two planes passing through the ray and the respective axes.

When the two axes are of equal intensity, and of the same character, the preceding law gives the very same results as the law of Huygens does for one axis placed at right angles to the other two.

From these views it follows as a necessary consequence, a consequence first deduced from them by M. Biot, that the difference of the squares of the velocities of the two rays are proportional to the product of the sines of the

Double Refraction.

angles which each of them make with the two resultant axes P and P′, and hence making these angles φ and φ', and V the velocity of the extraordinary, and v that of the ordinary ray, we shall have $V = (v^2 + a \sin.\varphi \times \sin.\varphi')^{\frac{1}{2}}$, a being a constant coefficient.

M. Fresnel's law.

M. Fresnel was led by theoretical considerations to suppose that in crystals with two axes, the law of double refraction was still more complicated; and he soon confirmed the accuracy of his views by direct experiment, and was thus able to establish a general law which embraced all crystals with one axis.

Our limits will not allow us to do more than give the following brief abstract of his labours, which we owe to M. Pouillet.[1]

When the light is incident in the plane perpendicular to AB, fig. 159, that is in the plane of CD, *one* of the *two* rays is regulated by the ordinary law of refraction, whereas when the ray is incident in the plane AB, perpendicular to the axis CD, the *other* of the two rays is regulated by the extraordinary law of refraction. The formulæ by which Fresnel expressed his law, are as follow:

making V=the velocity of the ordinary ray.
v=that of the extraordinary ray.
A=the angle of the ray with the one axis.
a=the angle of the ray with the other axis.
D=*ordinary* velocity in *uniaxal* crystals, or the *constant* velocity in the section perpendicular to CD, fig. 159, in *biaxal* crystals.
d'=the *extraordinary* velocity in *uniaxal* crystals, or the *constant* velocity in the section perpendicular to AB, fig. 159, then

$$V^2 = D^2 + (d^2 - D^2)\sin^2\tfrac{1}{2}(a - A)$$
$$v^2 = D^2 + (d^2 - D^2)\sin^2\tfrac{1}{2}(a + A)$$

In *uniaxal crystals*, when the *two* axes are reduced to *one*, we have A=a, so that

$$V^2 = D^2$$
$$v^2 = D^2 + (d^2 - D^2)\sin^2 A,$$

that is, the ordinary velocity is constant in all directions and equal to D, and, as the second equation indicates, the extraordinary velocity v depends on the angle A, which the extraordinary ray makes with the axis.

When this ray is in the section perpendicular to the axis, we have A=90°, and $\sin.^2 A = 1$, hence $V' = d$.

When the ray is parallel to the axis A=0°, and $\sin.^2 A = 0$, whence v=D, so that in this direction only the extraordinary becomes equal to the ordinary velocity.

In *biaxal crystals*, when the ray is in the section perpendicular to CD, fig. 159, it is evident that it always forms equal angles with the axes Pp, P′p'. Hence A=a, and $\sin.^2\frac{1}{2}(a - A) = 0$, consequently $V^2 = D^2$, or V=D. In this way D is the expression of the velocity in this case, and it is on this account that the term *ordinary velocity* is applied to all those which are given by the different values of V.

When the ray on the contrary, is in the section perpendicular to AB, the sum of the angles A and a is always equal to two right angles, and $\sin.\frac{1}{2}(A + a) = 1$, whence it follows that $V^2 = d^2$, and V=d, and it is on this account that the term *extraordinary velocity* is applied to all those that are given by the values of v.

When d is greater than D, the *minimum* of the ordinary velocity takes place when a=A, or when V=D, and the *maximum* takes place when a—A is the greatest possible, which happens in the plane of the axes APCBDP′. The *minimum* becomes the *maximum*, and *vice versa* when D is greater than d. The *maximum* and *minimum* for the extraordinary ray take place also, when $v = d$, and consequently for the case when the ray is in the plane of the axes, but they in like manner change their part when d is greater or less than D.

Double Refraction.

In every case the difference of the squares of the velocities is expressed by the formula

$$v^2 - V^2 = (d^2 - D^2)\sin.a.\sin.A.$$

That is to say, the two ordinary and extraordinary rays having a common direction, the difference of the squares of their velocities are proportional to the product of the sines of the angles which each of them makes with the two axes. "This remark, adds M. Pouillet, had been made by Sir David Brewster and M. Biot before Fresnel had pointed out the simple law which embraces the phenomena in all its extent."

List of the primitive forms of Crystals that have two axes of double refraction.

Crystals with two axes.

From a great number of experiments, Sir David Brewster found that the property of possessing *two* axes of double refraction belonged to all the crystals that are included in the *prismatic system* of Mohs, or which have the following primitive forms of Hauy:—

A right prism,	Base a rectangle.
.....	Base a rhomb.
.....	Base an oblique parallelogram.
Oblique prism	Base a rectangle.
.....	Base a rhomb.
.....	Base an oblique parallelogram.
Octohedron	Base a rectangle.
.....	Base a rhomb.

In these solids there is no single line or axis of symmetry.

The following table, which we could have enlarged considerably, contains most of the crystals with two axes, whose primitive forms have been determined by crystallographers:—

1. *List of Crystals of known Primitive Forms, and having* Two *Axes of Double Refraction.*

1. *Right Quadrangular Prism—Base a Rectangle.*

	Position of Principal Axis.	*Position of Second Axis.*
Cymophane, *Young.*	Axis of right prism.	Perp. to the sides.
Peridot, ditto.	Perp. to axis.	Axis of right prism.
Prehnite, ditto.		
Stilbite, ditto.	Parallel to longest side of prism, or perp. to best cleavage planes.	Axis of right prism, or perp. to longest faces.
Comptonite, *Brooke.*	Perp. to axis of right prism.	Axis of that prism, or other axis.
Thomsonite, ditto.	Perp. to axis of prism.	Axis of the prism.
Anhydrite, *Bournon.*	Axis of right prism.	Perp. to sides of prism
Tartrate of potash, ditto.	Perp. to the flat rhomb. faces.	Parallel to a side of rhomb. prism.
Staurotide, *Hauy.*		
Datholite, do.		
Mica, do.	Axis of right prism.	Greater diagonal of its rhomb. base.
Talc, do.	Axis of right prism.	Diagonal of its rhomb base.
Spodumene, do.	Axis of prism.	In plane of laminæ.
Sulphate of barytes, ditto.	Short diagonal of rhomb. base.	Long diagonal, or axis of prism.
Sulphate of strontian, do.	Axis of the prism.	Perp. to axis of prism.
Sulphate of soda, *Bournon.*		
Citric acid, do.		
Tartrate of potash and soda, do.		
Chromate of lead, do.		
Stilbite, *Brooke.*	Perp. to laminæ.	In plane of laminæ.
Mesotype of Auvergne, do.	Axis of prism.	Perpendicular to axis.

[1] *Elémens de Physique Expérim.* liv. viii. cap. 1.

Double Refraction

3. *Right Quadrangular Prism—Base an Oblique Parallelogram.*

Names of Minerals.	*Position of Principal Axis.*	*Position of Second Axis.*
Needlestone of Faroe, do.	Axis of prism.	Perpendicular to axis.
Sulphate of lime, *Hauy.*	In plane of the laminæ.	Axis of prism.
Epidote, do.	In base of prism.	Axis of prism.
Axinite, do.		
Heulandite, *Brooke.*		
Brewsterite, do.		
Sulphato-carbon of lead, do.	Perp. to laminæ.	In plane of laminæ.
Acetate of strontian.		

4. *Oblique Quadrangular Prism—Base a Rectangle.*

Borax, *Hauy.*
Euclase, do.

5. *Oblique Quadrangular Prism—Base a Rhomb.*

Diopside, *Hauy.*	Perpendicular to sides of the prism.	Axis of prism, or other axis.
Euclase, do.		
Augite, do.		
Glauberite.		
Grammatite.		
Sulphate of iron, *Wollaston.*		
Super-sulphate of potash, *Bournon.*	Perp. to axis of prism.	Axis of prism.
Acetate of copper, do.	Perp. to axis of prism.	Axis of prism.
Tartaric acid, do.	Axis of prism.	Perpendic. to faces.
Oxalic acid, do.		
Sugar, do.		
Hydrate of strontian.		
Bitartrate of potash.		
Sulphate of soda.		

6. *Oblique Quadrangular Prism—Base an oblique Parallelogram.*

Feldspar, *Hauy.*
Kyanite, do.
Sulphate of copper, do.

7. *Octohedron with a Rectangular Base.*

Nitrate of potash.	Axis of octohedron.	Perp. to sides of base
Arragonite.	Axis of prism or perpendicular to axis of octohedron.	Perp. to sides of base
Carbonate of lead.	In plane of base of two pyramids.	Axis of the octohedron.
Sulphate of lead.	Axis octohedron.	Perp. to sides of rect. base.
Topaz.		
Muriate of copper.	Long diagonal of rhomb. base.	Short diagonal of the rhomb. base.

8. *Octohedron with a Rhombic Base.*

Sulphur, *Hauy.*		
Sphene, do.		
Carbonate of soda, do.	Diagonal of base through o of Hauy, Pl. xxxix.	Axis of octohedron or other axis.

9. *Minerals belonging to the Prismatic System of Mohs, and having* TWO *axes, but not included in any of the above divisions of Hauy.*

Sulphate of magnesia, *Mohs.*	Cleavable diagonal of square base.	Perpendicular to axis, or the other diagonal.
Sulphate of manganese.		
Sulphate of zinc.	Axis of rhomboidal prism.	Short diagonal of rhomboidal base.
Sulphate of ammonia.	Axis of hexahed. prism.	Perp to axis.
Sulphate of cobalt.		
Carbonate of strontian, do.	Axis of prism.	Perp. to axis.
Carbonate of barytes, do.	Axis of prism.	Perp. to axis.
Diallage.	Perp. to plates.	Plane of plates.
Molybdate of ammonia.		
Muriate of barytes.		
Realgar.		
Orpiment.	In plane of laminæ.	Perp. to laminæ.
Lepidolite.	Perp. to laminæ.	Plane of laminæ.
Mesotype.	Axis of prism.	Perp. to axis.
Mesolite.	Ditto.	Ditto.
Serpentine.		
Natrolite.		
Sulphato-bi-carbonate of lead.	Axes of acute rhomb.	In plane of laminæ.
Phosphate of iron.	In plane of laminæ.	Perp. to laminæ.
Harmotome, Petalite, Chabasie.		

10. *Crystals, whose primitive form has not been determined, but which have been found to have two axes, and which must belong to the Prismatic System of Mohs.*

Iolite.	Axis of prism.	Perp. to axis of prism.
Indurated talc.	Perp. to plates.	In plane of laminæ.
Carbonate of potash.	Plane of axis perpendicular to the flat tables.	In plane of tables.
Carbonate of copper.		
Sulphate of ammonia and magnesia.	Shorter diagonal of the rhomboidal base.	Axis of hexagonal prism, or long diag. of rhomb. base.
Sulphate of soda and magnesia.		
Sulphate of nickel.	Short diagonal of the rhomboidal base.	Axis of prism, or other axis.
Oxy-nitrate of silver.	Perp. to rhomb plates	Long diagonal of rhomboidal plates.
Nitrate of ammonia.		
..... of lime.		
..... of strontian, with water of crystallization.		
..... of copper.		
..... of zinc.		
..... of mercury.		
..... of bismuth.		
Nitrate of lead, certain specimens.	Mr. Herschel, *Edin. Ph. Jour.* vol. ii. p. 184.	
Muriate of mercury.		
..... of magnesia.		
Acetate of lead.	Perp. to broad sides of prism.	Axis of prism, or other axis.
..... of zinc.	In plane of hexag. plates.	Perpendicular to hexag. plates.
..... soda.		
..... barytes.		
Phosphate of soda.		
Oxalate of ammonia.	Perp. to axis of prism.	Axis of prism.
Hyper-oxymuriate of potash.	Perpendic. to rhomb. plates.	Plane of axis in that diag.
Super-oxalate of potash.		
Super-chromate of potash.		
Crystallized Cheltenham salts.	Axis of prism.	Perp. to axis.
Murio-sulphate of magnesia and iron.	Cleavable diagonal of its square base.	Axis of prism, or other diag.
Benzoate of ammonia.	Perp. to laminæ.	In plane of do.
Benzoic acid.	Perp. to plates.	In plane of plates.
Chromic acid.		
Spermaceti.	Perp. to plates.	In plane of plates.
Boracic acid.	Perp. to hexag. plates.	In plane of plates.
Succinic acid.	Perp. to faces of flat prism.	In plane of these faces.
Super-tartrate of potash.	Perpendicular to axis of prism.	Axis of prism.
Tartrate of potash and antimony.	Perpendicular to axis of prism.	Axis of prism.
Camphor.		
Hydrate of barytes.	Perp. to flat plates.	In ane of plates.
Prussiate of potash.	Perp. to rect. laminæ.	In plane of laminæ.
Mother-of-pearl.	Perp. to laminæ.	In plane of laminæ.
Carbonate of ammonia.	Short diag. of rhomb, and perp. to best cleavage.	Axis of prism, or long diag.
Hyposulphite of lime.	Sir John Herschel, *Edin. Phil. Jour.* vol. i. p. 15.	
..... of barytes.	Sir John Herschel.	

Double Refraction

Polarization.

Sect. III.—On Crystals with three Axes of Double Refraction.

Crystals with three axes.

Having determined the primitive form to which those crystals belong which have *one* and *two* axes of double refraction, Sir David Brewster found that all those crystals which have no resultant axes belonged to that class of primitive forms which have three rectangular axes of form, namely, the *cube*, the *regular octahedron*, and the *rhomboidal dodecahedron*, or to the *tessular* system of Mohs. Since, however, every real axis of double refraction coincides with a prominent line in the primitive form of the crystal, he conceived that those crystals which had no apparent double refraction had actually *three equal rectangular axes*, the effect of which was to compensate each other at every point of the crystal, or, in other words, to have an infinite number of resultant axes.

In confirmation of these views, Sir D. Brewster found various indications of positive and negative doubly-refracting structures in *alum*, *diamond*, &c., as if these equal axes had not exactly compensated each other, either from the three not being perfectly equal, or from their not being placed accurately at right angles to each other.

The following is a list, which might be considerably extended, of the primitive forms of the crystals that have no double refraction.

Primitive Form a Cube.—Muriate of soda, muriate of potash, muriate of silver.

Primitive Form an Octahedron.—Diamond, fluor spar, muriate of ammonia, pleonaste, nitrate of lead, sulphate of alumina, soda, alum, ruby copper, spinelle, nitrate of strontian octahedral, nitrate of lead, nitrate of barytes, sulphate of ammonia and chromium, sulphate of ammonia and iron, sulphate of alumina and ammonia.

Primitive Form a Rhomboidal Dodecahedron.—Garnet, blende, sodalite, essonite, helvin, lazulite.

There are some crystals, such as *arseniate of iron, amphigene, analcime, boracite, aplome*, all of which have double refraction, and therefore cannot belong to the tessular system.

Sect. IV.—On Crystals with Planes of Double Refraction.

Crystals with planes of double refraction.

In all the crystals to which we have hitherto referred the double refraction is related to one or more axes; but Sir David Brewster has found that in *analcime*, a mineral ranked in the tessular system, there are several planes or sections of the crystal in which there is no double refraction, the double refraction increasing with the distance from these planes according to a law which will be afterwards mentioned. When the ray is incident in any direction that does not lie in one of these planes, it is separated into two images by double refraction. This is the only substance which is known to possess this remarkable property.

Part VII.—ON THE POLARIZATION OF LIGHT.

Polarization of light.

The light emitted from the sun, from a candle, or from any self-luminous body, before it has suffered reflection from, or refraction by, any body, is called *common light*. If we allow a beam of such light to fall upon any refracting or reflecting body, whether transparent or metallic, or to pass by any diffracting body, it will suffer precisely the same changes, whether its upper, its under, its right or its left side, or any other side of the beam, is turned towards the refracting, reflecting, or diffracting body. Hence it follows that this beam of light has the same properties in all its sides.

Now this is not true of all light. If the preceding beam of common light is reflected at a particular angle, from transparent bodies, or passes obliquely through a number of refracting surfaces, or is transmitted through certain crystals, or suffers total reflection from the second surfaces of transparent bodies, or from the surface of metals; in all these cases it has suffered such a change, that it no longer has the same properties in all its sides, but, on the contrary, exhibits distinct and remarkable properties in its different sides, or, what is the same thing, has *polarity*. This beam of common light is therefore said to be *polarized*. The different kinds of polarization which may thus be impressed upon common light are three,—viz., *plane polarization*, *circular polarization*, and *elliptical polarization*; or the whole of these three kinds of polarization may be included in the general name of *elliptical polarization*, which becomes *circular* when the two axes of the ellipsis are equal, and *rectilineal* or *plane* when the minor axis of the ellipse is infinitely small. We shall now proceed to explain the phenomena of these three kinds of polarization in their order.

Polarization.

Chap. I.—ON PLANE POLARIZATION.

There are four ways by which common light may be *plane polarized*.

Plane polarization.

1. By double refraction.
2. By one reflection from transparent bodies.
3. By several refractions through transparent surfaces.
4. By the absorption or dispersion of part of the light.

These various processes exhibit many interesting phenomena and laws. which we shall proceed to explain.

Sect. I.—On the Polarization of Light by Double Refraction.

Polarization by double refraction.

The polarization of light by the double refraction of Iceland spar was discovered by Huygens. Upon examining the two pencils O*o*, E*e* (fig. 148) formed by double refraction, he found that they had different properties on different sides, and that both of them differed from common light, as well as from one another. He discovered this difference in the following manner:—

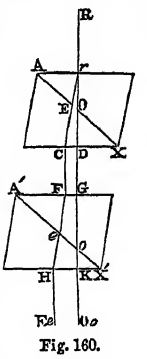


Fig. 160.

Having taken two pieces of Iceland spar, he placed them symmetrically, as in fig. 160, with all the faces of the one parallel to all the faces of the other, A*r*X, A'GX' being the principal sections of two rhombs. A ray of common light R*r*, incident upon the first crystal at *r*, is divided into two pencils *r*C, *r*D, O being the ordinary and E the extraordinary ray, as formerly explained. Now the ordinary ray DG, falling upon the second crystal at G, and the extraordinary one CF at F, should have been each subdivided by double refraction into two pencils by that crystal; but they are not, the *ordinary* ray DG being *only* refracted *ordinarily*, and the *extraordinary* ray CF *only extraordinarily*, as seen in the figure, where these rays FH, GK, emerge singly at H and K, the one an *ordinary* and the other an *extraordinary* ray. If the upper rhomb remains fixed while the under one is turned round 90°, so that its principal section is perpendicular to that of the upper one, as shown in fig. 161, the same phenomena will take place, with this difference only, that the ray DG, refracted *ordinarily* by the *first* crystal, is refracted *extraordinarily* by the *second*, and the ray CF, refracted *extraor-*

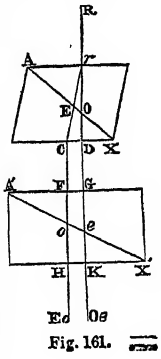


Fig. 161.

Polarization.

dinarily by the *first* crystal, is refracted *ordinarily* by the *second*.

Hence it is manifest that the ray of common light R*r*, and the two doubly-refracted pencils CF, DG have all different properties. For if R*r* were to fall upon the second rhomb, it would be divided into two pencils; whereas CF and DG refuse to be so divided, and are each refracted in different ways by the second crystal.

Now, in *every other position* of the four rhombs, between the two where their principal sections are *parallel* or *perpendicular* to one another, the two pencils CF, DG are divided into two pencils, and *four* separate pencils emerge from the second rhomb.

In order to understand the phenomena presented by these *four* pencils, when the second rhomb performs a complete revolution behind the first one, let us suppose that the lower rhomb begins to revolve from the position in fig. 159, which we shall call 0° of azimuth, and in which case we shall have two horizontal pencils HE, KO (fig. 161), whose sections[1] are shown in the annexed figure at B, opposite 0°, A representing the appearance of the aperture through the first rhomb. When the second rhomb has just begun to move out of its position of parallelism to the first, two extremely faint images begin to appear between the other two; and at 22½° of azimuth they will appear as at C. At 45° of azimuth their intensity will be equal as at D; at 67½° the two most distant ones will have become the faintest; and at 90° the four images will be reduced to two, this being the position shown in fig. 160. By continuing to turn the second rhomb, other two faint images start up, which at 112½° appear as at G; at 135° the four images are equally bright, as at H; at 157½° the two outermost are the faintest; and at 180° they all coalesce into one bright image, as at K, having twice the brightness of either of those at A or F, and *four* times the brightness of any one of the four at D or H.

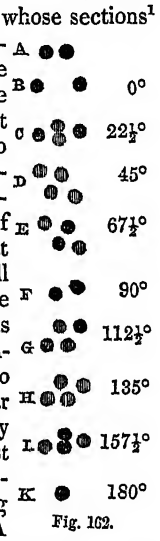


Fig. 162.

Malus' law of intensity.

In making the preceding experiment, it will be seen that two of the images gradually increase in brightness, while other two gradually diminish. Malus investigated the law of the intensity for these images, both when the pencil of common light is incident perpendicularly and obliquely. Our limits will permit us to give only the simplest case, making

o = ray refracted *ordinarily* by the *first* rhomb.
e = the ray refracted *extraordinarily* by the *first* rhomb.
oo = the ray refracted *ordinarily* by the *first* rhomb, and *ordinarily* by the *second*.
oe = the ray refracted *ordinarily* by the *first* rhomb, and *extraordinarily* by the *second*.
ee = the ray refracted *extraordinarily* by the *first* rhomb, and *extraordinarily* by the *second*.
eo = the ray refracted *extraordinarily* by the *first* rhomb, and *ordinarily* by the *second*.
Q = the quantity of light contained in the incident ray.
$(1-m)Q$ = the quantity of light absorbed by the first rhomb.
P = the intensity of any of the pencils.
P_o = the intensity of the *ordinary* emergent ray.
P_e = the intensity of the *extraordinary* emergent ray.

Then, since the quantity of light contained in the two emergent rays is equal to the incident light diminished by the quantity absorbed, we shall have $Q-(1-m)Q=mQ$; and since the light is equally divided between the two pencils, we obtain $P_o=\frac{1}{2}mQ$, and $P_e=\frac{1}{2}mQ$.

But the quantity of light mQ which falls upon the second rhomb will be reduced by absorption to $mQ-(1-m)mQ=m^2Q$; consequently, if a is the angle formed by the principal sections of the two rhombs, we shall have

Polarization.

First pencil, $P_{oo}=\frac{1}{2}(m^2Q\cos^2 a)$.
Third pencil, $P_{ee}=\frac{1}{2}(m^2Q\cos^2 a)$.
Second pencil, $P_{oe}=\frac{1}{2}(m^2Q\sin^2 a)$.
Fourth pencil, $P_{eo}=\frac{1}{2}(m^2Q\sin^2 a)$.

When the principal sections of the two rhombs are parallel, then $a=0$, and $\sin^2 a=0$, consequently $P_{oe}=0$, and $P_{eo}=0$; that is, *the third and fourth pencils will disappear*.

When, on the contrary, the principal sections are at right angles to one another, $a=90°$, and $\cos^2 a=0$, consequently $P_{oo}=0$, and $P_{ee}=0$; that is, *the first and second pencils will disappear*.

When the incident ray is not perpendicular to the surface of the first rhomb, the intensities of the pencils are functions of the angles of incidence and the angle which the ray forms with the principal sections.

All the phenomena above described may be produced by combining any two *positive* and any two *negative* crystals; but if a positive is combined with a negative crystal, the same effects will be produced when the principal sections are at right angles to each other, as when they are parallel in the other cases.

The difference between common and polarized light, as evinced by the phenomena of double refraction, is, that the former may always be divided into two pencils by a doubly-refracting crystal, whereas the latter is not capable of being so divided under certain circumstances.

As the four polarized pencils, when united, as at K (fig. 162), produce a pencil of common light, or rather a pencil which cannot be distinguished from common light, it is highly probable that the Iceland spar, in converting common into polarized light, by refracting it into two pencils, has not communicated to it any new property, but has merely separated it into its two elements, just as a prism separates a pencil of white light into its seven elementary colours by refraction, these colours again forming white light by their re-union.

Sect. II.—On the Polarization of Light by Reflection.

Polarization by reflection.

We have already stated, in the *History* of Optics, the manner in which the celebrated French philosopher Malus rediscovered the polarization of light by reflection. Upon repeating his experiments with a variety of opaque and transparent bodies, not metallic, such as glass, water, &c., he found that, *when light was reflected at a particular angle from such bodies, it was polarized exactly like one of the pencils formed by double refraction*, the pencil polarized by reflection having all its properties identically the same with that of the doubly-refracting crystal. Like the latter, it was no longer capable of being divided into *two* pencils by a rhomb of Iceland spar; and as, in the polarization of light by the double refraction of one crystal, that property depends on the angle formed between the principal sections of the two crystals, as shown in figs. 160 and 161, so in the present case the polarization depends on the angle formed between *the plane of reflection* and that of the principal section of the crystal which polarizes the light. In all such phenomena, indeed, as Malus remarks, the *plane of reflection* replaces the plane of the principal section of the crystal.

If we receive the ray polarized by reflection from water at an angle of 52° 45′ upon any crystal having double refraction, it will not be divided into two pencils when the plane of reflection is parallel to the principal section, as if it had been a pencil of common light; but it will be re-

[1] If we place a circular aperture, the size of the little dark circles in fig. 162, at *r* (fig. 161), the images will have that form.

Polarization.

fracted entirely, according to the ordinary law, as if the crystal had lost the power of double refraction. If, on the other hand, the principal section of the crystal is perpendicular to the plane of reflection, the reflected ray will be refracted wholly, according to the law of extraordinary refraction. In all intermediate positions it will be divided into two rays, according to the same law, and in the same proportions, as if it had acquired its new character by the influence of double refraction.

In order to analyse this phenomenon completely, he placed the principal section of a crystal vertically; and after having divided a ray into two by it, he made these two rays fall on the surface of *water* at an angle of 52° 45′. The ordinary ray was partially reflected, like common light, but *the extraordinary ray penetrated the water wholly, and not a single particle of it was reflected.* When the principal section of the crystal was, on the contrary, perpendicular to the plane of incidence, the *extraordinary* ray was partially reflected, and *the ordinary ray was wholly refracted.*

Malus found the phenomena to be the same for all other transparent bodies, whether solid or fluid; but the angle at which light experienced this modification was in general greater in bodies which refracted light most. Below and above this limit the rays were more or less modified.

This property of reflected light takes place at a different angle for pencils reflected at the *second surfaces* of bodies, and the sine of the angle at the first surface is to the sine of the angle at the second as the sine of incidence is to the sine of refraction. Hence, in parallel plates, either of glass or other bodies, the two pencils which are reflected in the same directions from both surfaces have equally received this new property, and the light which has received it is said to have been *polarized by reflection.*[1] M. Malus found the same property in black bodies, such as *black marble, ebony,* &c.[2]

Malus next proceeded to study the phenomena when the light R, polarized by one plate of glass A, was reflected from a second plate C (fig. 163), the ray RA being incident on the first plate, and the polarized ray AC on the second plate, at an angle of 56°, the polarizing angle of glass. In the case shown in the figure, the plane of reflection ACE, from the plate C, is at right angles to the plane of reflection RAC from the first plate, and in this case the reflected pencil CE wholly vanished, all the reflected and polarized light AC having penetrated the glass at C. If we now turn round the plate C from this point, or *zero*, into different azimuths, so that it is always equally inclined to the polarized ray, a small portion of the ray AC will be reflected from C, and this portion will increase till it becomes a maximum, when the plane ACE is parallel to RAC, or in the azimuth of 90°. By continuing to turn the plate C, the reflected ray CE will gradually diminish, and when C has reached the azimuth of 180° its plane of reflection will be perpendicular to that of A, and the reflected ray CE will wholly disappear. In advancing from 180° to 270°, CE will again reach its maximum, and at 360°, when it has returned to its position, as in the figure, it will again return to its minimum.

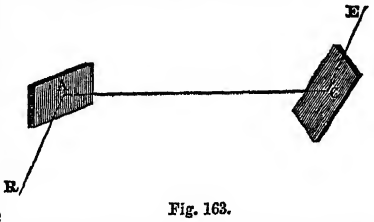


Fig. 163.

While the reflected pencil CE passes from its *minimum* intensity at 0° and 180°, to its maximum at 90° and 270°, Malus supposes the intensity to vary as the square of the cosine of the angle of azimuth, or of any even power of the cosine. Calling a the angle of azimuth which the plane of the second reflection makes with a plane perpendicular to RAC, I the maximum intensity of the reflected pencil, and P the intensity corresponding to any azimuth a, then $P = I \cos^2 a$. If we make a equal to 0°, 90°, 180°, and 270°, we shall have, when $a = 0°$, $\cos a = 1$, $\cos^2 a = 1$, $\cos^4 a = 1$, and consequently $P = I$, or the reflected pencil is a maximum. When $a = 90°$, $\cos a = 0$, $\cos^2 a = 0$, $\cos^4 a = 0$, and $F = 0$; that is, the reflected pencil wholly disappears.

Polarization.

It is obvious, from the arrangement of glasses in fig. 163, that if the light R proceeds from the sky, an observer with his eye placed at E will see a black spot in the part of the sky from which the light R comes, as the whole of the light penetrates the plate C. If the light R comes from a house, the house will disappear if it is at a considerable distance; and by turning round C, the house will have its greatest brightness when the two planes of reflection are parallel. If, in the position when the house was invisible, we breathe upon the plate C, the house will suddenly become visible, and will again disappear when the breath has evaporated. If we now place the plate C at an angle of 52° 45′ to the ray AC, the house will be seen; but if we again breathe upon C, the house will disappear. The cause of these phenomena is, that by breathing upon C we make the reflecting surface an aqueous one, which refuses to reflect light at an angle of 52° 45′, but reflects it at 56°.

If we place beside each other two sets of reflectors arranged in the manner shown in fig. 163, C being inclined in the one set 56° to A, and in the other set 52° 45′, and the plates C, C being near each other, we may, by breathing upon each at the same time, exhibit the paradoxical phenomenon of reviving and extinguishing a luminous image by the same breath, or we may appear to breathe at the same time light and darkness.[3]

1. *On the Law of the Polarization of Light by Reflection.*

Law of polarization by reflection.

After determining the angle at which different bodies polarized light, Malus concluded that "this angle followed neither the order of refractive powers nor that of the dispersive forces, and that it was a property of bodies independent of the other modes of action which they exercised over light.[4]

Law of the tangents.

In repeating the experiments of Malus, Sir David Brewster measured the polarizing angles of a great number of bodies, but experienced many difficulties in connecting them together by a simple law. In some substances the light was not completely polarized at any angle. In others purple and blue light was left at the polarizing angles; and in various specimens of glass different parts of the same surface gave different polarizing angles. The first of these phenomena he ascribed to the circumstance that the differently coloured rays of white light were polarized at different angles; and the second he found to arise from changes that had taken place on the surfaces of glass by partial decomposition, owing to the action of the atmosphere. By rejecting those substances where the action of the surface was thus masked or disturbed, he was led to the following general law, that *the index of refraction of any body is the tangent of its angle of polarization.*

The following were the experiments on which this law was founded:—

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[1] *Théorie de la Double Refraction*, sect. 48.

[2] Ibid., sect. 50.

[3] This experiment was described by Sir David Brewster in the *Edin. Phil. Journal*, vol. vii., p. 146. See also his *Letters on Natural Magic*, p. 125.

[4] *Bull. de Sciences de la Soc. Philos.*, Juin 1811, No. xlv., tom. ii., p. 294.

Polarization.

Names of the Bodies.	Observed Polarizing Angles.	Calculated Polarizing Angles.
Air	45° or 47°	45° 0′ 32″
Water	52	59[1] 53 11
Fluor spar	54	50 55 9
Obsidian	56	3 56 8
Sulphate of lime	56	28 56 45
Rock-crystal	57	22 56 58
Sulphate of barytes	58	29 58 33
Opal-coloured glass	58	1 58 33
Topaz	58	40 58 34
Mother-of-pearl	58	47 58 50
Iceland spar	58	23 58 51
Orange-coloured glass	59	12 59 28
Spinelle ruby	50	6 60 25
Zircon	63	8 63 0
Glass of antimony	64	45 64 30
Sulphur	64	10 63 45
Diamond	68	2 68 1
Chromate of lead	67	42 68 3

Upon repeating these experiments with homogeneous light, Sir David Brewster also found that the angle of polarization varied with the refrangibility of the light, and that the tangent of the polarizing angle was equal to the index of refraction of the light employed.

Hence we are able to explain why, at the maximum polarizing angle, a portion of unpolarized light must always remain, and why this portion increases with the refractive and dispersive power of the body. This will be understood from the following table :—

Index of Refraction.	Colour of the Light.	Polarizing Angle.	Variation.
	Water.		
1·330	Red	53° 4′	
1·336	Green, or mean ray	53 11	...0° 15′
1·342	Violet	53 19	
	Plate-Glass.		
1·515	Red	56 34	
1·525	Green	56 45	...0 21
1·535	Violet	56 55	
	Oil of Cassia.		
1·597	Red	57 57	
1·642	Green	58 39	...1 24
1·687	Violet	59 21	

Now it is obvious, that when the *green* or mean, or most luminous ray, is polarized, and therefore vanishes, neither the red nor the violet has wholly vanished, and consequently a portion of unpolarized light, composed of a portion of these two colours, will still be visible. In oil of cassia the quantity of light is considerable, and is of a fine *blue*.

Dr A. Seebeck's experiments.

In 1830, Dr A. Seebeck of Berlin published a series of very accurate and valuable experiments made by means of an instrument constructed for the purpose, which, if any doubts had existed about the accuracy of the preceding law, were sufficient to remove them. Dr Seebeck's principal object seems to have been to obtain accurate measures of the polarizing angle of different glasses, when the surfaces were newly polished, in order to reconcile the law to that class of bodies in which the deviations had been found to arise from some chemical or mechanical changes produced upon their surface. The following table contains Dr Seebeck's experiments :—

Names of the Bodies.	Index of Refraction.	Polarizing Angles. Observed.	Calculated.
Fluor spar, colourless	1·4341	55° 6′·7	55° 6′·7
„ greenish-blue	1·4343	55 3·8	55 7·0
Common opal	1·4516	55 29·3	55 26·3
Plate-glass, English, colourless	1·5130	56 36·0	56 32·2
„ colourless	1·5266	56 45·5	56 46·4
Crown-glass, English	1·5321	56 50·2	56 52·0
„ ditto	1·5523	57 12·6	57 12·6
Flint-glass, English	1·5783	57 41·0	57 38·5
„ ditto	1·6206	58 16·6	58 19·4
Pyrope	1·8131	61 4·0	61 7·7
Yellow blende	2·3692	67 8·2	67 7·0

Upon examining the polarizing angles of different specimens of glass at different periods after the surfaces were polished, Dr Seebeck confirmed the explanation given by Sir David Brewster, of the variations in their polarizing angles.[2]

Polarization.

When a pencil of light is polarized by reflection, the sum of the angles of incidence and refraction is a right angle.

Let MN (fig. 164) be the reflecting surface, and BA a ray of light polarized by reflection in the direction AD, and let AC be the refracted ray. Then, since EF, the tangent of the polarizing angle BAE, is equal to m, or the index of refraction, we have, by the law of the sines, $CL = \frac{BG}{m} = \frac{BG}{EF}$. But from the similar triangles ABH, AEF, we have AH, or BG : HB :: EF : rad., and $HB = \frac{BG}{EF}$; consequently CL = HB, and the angle BAN = CAK. But EAB + BAN = 90°; consequently EAB + CAK = 90°. Hence the complement of the polarizing angle is equal to the angle o refraction.

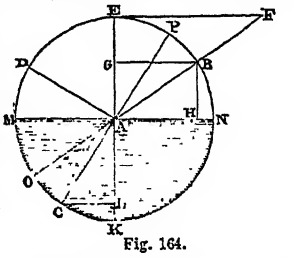


Fig. 164.

When a ray of light is polarized by reflection, the reflected ray forms a right angle with the refracted ray.

Since the angles DAM, BAN, CAK, are equal to one another, the angle DAC is equal to the right angle MAK; hence the reflected ray AD forms a right angle with the refracted ray AC.

When a pencil of light is incident on the second surface of transparent bodies, at an angle whose cotangent is equal to the index of refraction, the reflected portion will be either wholly polarized, or the quantity of polarized light which it contains will be a maximum.

As the images formed by the first and second surfaces of a transparent plate are simultaneously polarized, this proposition is established by the experimental results in the preceding table.

The angle of polarization at the second surface of transparent bodies is the complement of the angle of polarization at the first surface.

As the angle of incidence at the second surface is equal to the angle of refraction at the first surface, and as this latter angle is equal to the complement of the angle of polarization, it follows that the two polarizing angles are complementary to each other.

When a ray of light is polarized by reflection from the second surface of transparent bodies, the reflected ray will form a right angle with the refracted ray.

Let AB (fig. 165) be a ray incident at the first surface MN, AD the ray polarized at that surface, AC the ray incident at the second surface PQ, and CM the ray polarized at that surface; then, if CF be the refracted ray, the angle MCF is a right angle. But DAC is a right angle, and on account of the parallelism of MN, PC, and BA, CF, the angle FCP is equal to DAM; but MCP is equal to MAC; hence the whole MCF is equal to the whole DAC, or a right angle.

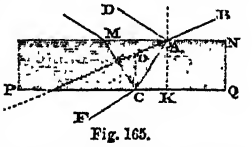


Fig. 165.

Cor. 1.—The ray MC, reflected by the second surface, is at right angles to the ray AB incident on the first surface.

Cor. 2.—The internal reflected ray CM forms with the external reflected ray AD an angle equal to the angle of deviation CAO.

[1] Mean of four observations by Malus, Biot, Arago, and Brewster.

[2] See Poggendorf's *Annalen*, 1830, No. ix., p. 27; or *Edin. Jour. of Science*, N.S., vol. v., p. 99.

Polarization.

Cor. 3.—The ray CF, emerging from the second surface, forms, with the first reflected ray AD, an angle equal to the complement of the angle of deviation.

When a pencil of light is incident upon the separating surface of two media having different indices of refraction m, m', *it will be polarized at an angle whose tangent is equal to the quotient of the greater index of refraction divided by the lesser, or* $\frac{m}{m'}$, *if* m *exceeds* m'.

This truth is a necessary consequence of the general law, and was also deduced from direct experiment. If the uppermost of the two media is a parallel plate, such as water lying upon a horizontal surface, &c., the separating surface of the two media cannot, at any angle of incidence upon the first surface, completely polarize the incident light, unless the sine of the angle whose tangent is $\frac{m}{m'}$ is, when multiplied by m, less than unity. Thus, in the case of water and glass the polarizing angle is 68° 47', but no ray incident upon the water, even at 90°, can fall at such an oblique incidence upon the glass as 48° 47'. For sin 48° 47' × m' (or the angle of refraction at an incidence of 90) is = 1·0048. When the upper medium has a higher refractive power than the lower, and lies in a parallel plate upon it, the same law is applicable, with this difference, that the ray is now polarized at the *second surface* of the denser medium, and the angle of polarization is that whose cotangent is equal to the index of refraction $\frac{m}{m'}$ of the separating surfaces.

Partial polarization.

In the preceding observations, we have considered only the light which is incident at the polarizing angle. It becomes interesting to inquire, what is the condition of the light which is incident at angles above and below the polarizing angle. Malus, Arago, Biot, Fresnel, and other distinguished philosophers, considered the light thus reflected as consisting of two pencils, one of which preserved its state of common light, while the other pencil was polarized in the plane of incidence. In the year 1815, however, Sir David Brewster was led, by direct experiments, to a very different opinion, namely, that the pencil of light which was supposed to have preserved its character of common light had *suffered a physical change in its condition, or had acquired in various degrees a character approaching to complete polarization.* He found, for example, that a pencil of light reflected from glass, either at 62° 30' or 50° 20', was so far polarized that it was wholly polarized by a second reflection at either of these angles; whereas, had the unpolarized part been common light, it could not have been polarized at any angle but 56° 45'. In like manner, he found that *three* reflections at 65° 33' or 46° 30', and *four* at 67° 33' or 43° 51', polarized the whole pencil; and in general he found *that a ray of light partly polarized by reflection at any angle, will be more and more polarized by every successive reflection in the same plane till its polarization is complete, whether the reflections are made at angles all above or all below the polarizing angle.*

These views were not acceded to by philosophers, though founded on direct experiment; and, so late as 1825, Sir John Herschel, in discussing the question, gives his decision in favour of the opinion held by the French philosophers.[1] Sir David Brewster was therefore induced to repeat and extend his experiments, and succeeded in confirming his original view of the subject. A brief account of these experiments will form the subject of the next section.

2. *On the Motion of the Plane of Polarization by Reflection.*

Polarization.

Motion of the plane of polarization.

MM. Fresnel and Arago, and Sir David Brewster, were engaged about the same time in inquiries upon this subject. If we suppose a pencil of polarized light polarized in a plane inclined 45° to a vertical line, and if we reflect it at different angles from a transparent surface in which the plane of reflection is perpendicular to the horizon, the plane of polarization will be gradually reduced from 45° to 40°, 35°, 30°, 25°, &c., as we diminish the angle of incidence from 90° till we reach the polarizing angle, when the plane of polarization will be inclined 0°, or will be brought into the plane of reflection. At angles less than the polarizing angle the plane continues to turn in the same direction, till at 0° it is again inclined 45° to a vertical plane, or to the plane of reflection, having performed a revolution of 90°, the first 45° during the change of incidence from 90° to 56° 45', and the other 45° from 56° 45' to 0°.

M. Fresnel represented these changes by the following law: i being the angle of incidence, i' the angle of refraction, x the primitive inclination of the plane of the polarized ray to the plane of reflection, and ϕ the inclination to which that plane is brought by reflection.

$$\text{Tan } \phi = \tan x \frac{\cos (i+i')}{\cos (i-i')}.$$

When $x = 45°$, tan $x = 1$, and

$$\tan \phi = \frac{\cos (i+i')}{\cos (i-i')}.$$

In these formulæ founded on the law of the tangents, $i+i'$ is the supplement of the angle which the reflected ray forms with the refracted ray, while $i-i'$ is the deviation produced by refraction.

These formulæ were verified by M. Arago at *ten* angles of incidence upon *glass*, and *four* upon *water*; but his experiments were made only in the case where $x = 45°$, and where tan x disappears from the formula. As Sir David Brewster's experiments embrace a wider range of substances, and also required care where x varies from 0° to 90°, they are a better basis for a law of such extensive application.

The following are the observations with glass and water made by M. Arago, in which $x = 45°$:—

Glass.

Angles of Incidence.	Inclination of Plane of Polarization to Plane of Reflection. Observed.	Calculated.	Difference.
24	38° 55'	37° 54'	−1° 1'
39	24 38	24 38	+0 3
49	11 45	10 52	−0 53
60	5 15	5 29	−0 14
70	19 52	20 24	−0 32
80	32 45	33 25	−0 40
85	38 55	39 19	−0 24
87	40 55	41 36	−0 41
88	41 15	42 44	−1 29
89	44 35	43 52	+0 43

[1] *Treatise on Light*, sect. 866, 867.

Polarization.

Water.

Angles of Incidence.	Inclination of Plane of Polarisation to Plane of Reflection. Observed.	Calculated.	Difference.
60	10° 20′	10° 51′	—0° 31′
70	25 20	24 48	+0 32
80	36 20	35 49	+0 21
85	40 50	40 32	+0 18

The following observations were made by Sir David Brewster on glass.

Glass.

90°	45° 0′	45° 0′	0° 0′
88	43 4	42 49	+0 35
86	40 43	40 36	+0 7
84	38 47	38 22	+0 25
80	33 13	33 46	—0 33
75	28 45	27 41	+1 4
70	22 6	21 3	+1 3
65	14 40	13 53	+0 47
60	6 10	6 16	—0 6
56	0 0	0 0	0 0
50	9 0	9 0	0 0
45	16 55	16 31	+0 24
40	22 37	23 1	—0 24
30	32 25	33 19	—0 54
20	39 0	40 4	—1 4
10	44 0	43 49	+0 11

Diamond.

90° 0′	45° 0′	45° 0′	0° 0
85 0	34 30	33 56	+0 34
80 0	24 0	23 12	+0 48
75 0	14 30	13 8	+1 22
70 0	4 30	3 54	+0 36
67 43	0 0	0 0	0 0
60 0	12 30	11 41	+0 49
50 0	24 0	23 30	+0 30

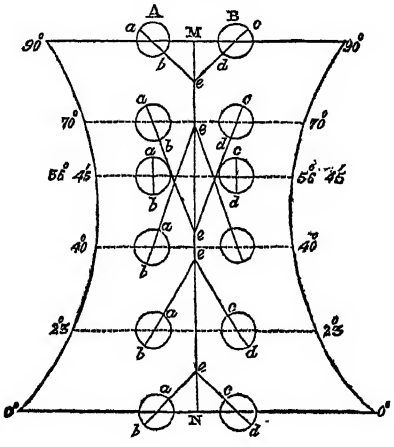
Our author also made another series of experiments, which confirms the general formula. As $x = 45°$ in the preceding experiments, he wished to observe the law of variation for φ when x varied from 0° to 90°. He took a crystal of quartz with a fine natural face parallel to the axis, and he found, that at an angle of incidence of 75°, and when x was $= 45°$, the inclination of the plane of polarisation to the plane of reflection was 26° 20′. We have therefore $\frac{\cos.(i+i')}{\cos.(i-i')} = \text{tan. } 26° 20'$, and consequently the general formula becomes tan. $\varphi =$ tan. x. tan. 26° 20′, by which the third column in the following table has been calculated.

Values of x.	Inclination of Plane of Polarisation. Observed.	Calculated.	Difference.
0	0° 0′	0° 0′	0° 0′
10	4 54	4 29	+0 25
20	10 0	10 16	—0 16
30	15 50	16 2	—0 12
35	20 0	19 12	+0 48
40	23 30	22 40	+0 50
45	26 20	26 27	—0 7
50	30 0	30 40	—0 40
55	35 30	35 23	+0 7
60	40 0	40 45	—0 45
70	53 0	53 49	—0 49
80	70 0	70 29	—0 29
90	90 0	90 0	0 0

It is a curious circumstance, that at an incidence of 45° the deviation produced by refraction, or $i - i'$, is, *in every substance*, the complement of the angle of refraction i' to 45°; and in the action of all substances in turning round the planes of polarisation, at an incidence of 45°, the angle of rotation, when the plane of the polarised ray is $\pm$ 45°, is equal to the angle of refraction, while the new inclination of the plane of polarisation to the plane of reflection, or φ, is equal to the deviation $i - i'$. Polarization.

These phenomena may be represented to the eye as in fig. 166, where MN represents the plane of incidence divided into ninety equal parts, and *ab*, *ab*, *ab* the planes of

Fig. 166.



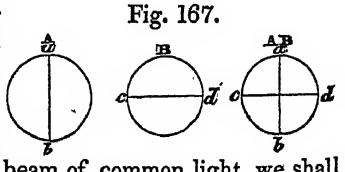
polarisation of the same pencil of light incident at the angles marked upon the curve line. At 90° of incidence, for example, the pencil A has its plane of polarisation inclined 45° to the plane of reflection M; but at 70° the same plane is inclined only 21°, and at 56° it is inclined 0°. At 40° it is inclined 23° in another direction; at 23° about 38°, and at 0° it is inclined 45°.

3. *On the partial Polarisation of Light, and the Law of its Intensity.*

In order to apply these results, Sir David Brewster conceives common light to be composed of two pencils A, B, fig. 166, having their planes of polarisation *ab*, *cd* at right angles to each other, and of equal intensity. Two such pencils united comports itself under all circumstances exactly like common light. We are as much entitled to consider a beam of common light as composed in this manner, as we are to regard white light as composed of seven differently refrangible rays. The prism analyses the one, and doubly-refracting crystals, and the action of transparent surfaces, analyse the other, and common light is recomposed by the two oppositely polarised pencils, as much as white light is recomposed by the union of the seven coloured rays. Considering common light in this manner, Sir David Brewster was led to obtain an explanation of the phenomena of polarisation produced by reflexion and refraction.

A beam of common light will be represented as at AB, composed of the two beams A, B, *ab* and *cd* being the planes of polarisation of each of them. In order, however, to analyse the action of a reflecting surface in changing the physical condition of the beam of common light, we shall represent it as in fig. 166, where the planes of polarisation *ab*, *cd* are each inclined 45° to the plane of incidence MN. These two beams are obtained from a rhomb of Iceland spar, upon one of whose surfaces is placed an aperture of the size of A or B, and the rhomb is turned round till its principal section is inclined 45° to the plane of incidence

Fig. 167.



Polarization.

MN. In this position the double beam or pencil AB will turn its planes of polarization as in fig 136.

At an incidence of 90°, or as near it as possible, no change is produced in the pencils A, B, the angle *aec* being still 90°. At an incidence of 80° the angle *aec* is reduced from 90° to 66°; at 70° it has been reduced to 40°; and at 56°, the maximum polarising angle, it has been reduced to 0°, or the planes of polarization *ab*, *cd* being now parallel, or, what is the same thing, the whole of the reflected pencil being polarised in the plane of incidence. Below the polarising angle, the planes *ab*, *cd* continuing to turn in the same direction, are again inclined to each other. At 40° they are inclined 50°; at 23° they are inclined 38°; and at 0°, or a perpendicular incidence, they are again brought back to their primitive inclination of 90°, or the state of common light. The two curves in the figure show the progressive change which takes place in the planes of polarisation, these planes being a tangent to the curve at the incidence which corresponds to any particular part of it.

"Such," says Sir David Brewster,[1] "being the action of the reflecting forces upon A and B taken separately, let us now consider them as superposed and forming natural light. At 90° and 0° of incidence, the reflecting force produces no change in the inclination of their axes or planes of polarisation; but at 56° in the case of glass, and 67° 43′ in the case of diamond, the axes of all the particles are brought into a state of parallelism with the plane of reflection; and consequently when the image which they form is viewed by the rhomb of calcareous spar, they will all pass into the ordinary image, and thus prove that they are wholly polarised in the plane of reflection.

"Hence we see that the total polarisation of the reflected pencil at an angle whose tangent is the index of refraction, is effected by turning round the planes of polarisation of one half of the light from right to left, and of the other half from left to right, each through an angle of 45°. Let us now consider what takes place at those angles where the pencil is only partially polarised. At 80°, for example, the angle of the planes *a b*, *c d* is 66°, that is, each plane of polarisation has been turned round in opposite directions from an inclination of 45° to one of 33° with the plane of reflection. The light has therefore suffered a physical change of a very marked kind, constituting now neither natural nor polarised light. It is not natural light, because its planes of polarisation are not rectangular; it is not polarised light, because they are not parallel. It is a pencil of light having the physical character of one half of its rays being polarised at an angle of 66° to the other half. It will now be asked how a pencil thus characterised can exhibit the properties of a partially polarised pencil, that is, of a pencil part of whose light is polarised in the plane of reflection, while the rest retains its condition of natural light. This will be understood by placing the analysing rhomb, with its principal section, in the plane of reflection, and viewing through it the images A and B at 80° of incidence. As the axis of A is inclined 33° to MN or the section of the rhomb, the ordinary image of it will be much brighter than the extraordinary image, the intensity of each being in the ratio of $\cos.^2 \varphi$ to $\sin.^2 \varphi$, φ being the angle of inclination, or 33°, in the present case. In like manner, the ordinary image of B will be in the same ratio brighter than its extraordinary image, that is, by considering A and B in a state of superposition, the extraordinary image of a pencil of light reflected at 80° will be fainter than the ordinary image in the ratio of $\sin.^2 33°$ to $\cos.^2 33°$. But this inequality in the intensity of the two pencils is precisely what would be produced by a compound pencil, part of which is polarised in the plane of reflection, and part of which is common light.

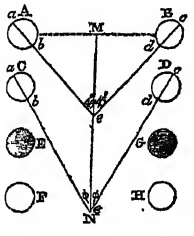
Polarization.

When Malus, therefore, and his successors analysed the pencil reflected at 80°, they could not do otherwise than conclude that it was partially polarised, consisting partly of light polarised in the plane of reflection, and partly of natural light. The action of successive reflections, however, afforded a more precise means of analysis, in so far as it proved that the portion of what was deemed natural light had in reality suffered a physical change, which approximated it to the state of polarised light; and we now see that the portion of what was called polarised light was only what may be called apparently polarised; for though it disappears, like polarised light, from the extraordinary image of the analysing prism, yet there is not a single particle of it polarised in the plane of reflection.

"These results lead to conclusions of general importance. The quantity of light which disappears from the extraordinary image, is obviously the quantity of light which is really or apparently polarised at a given angle of incidence; and if we admit the truth of the law of repartition discovered by Malus, and represented by $P_{oo} = P_o \cos.^2 \varphi$, and $P_{oe} = P_o \sin.^2 \varphi$, and as we can determine φ for substances of every refractive power, and for all angles of incidence, we may consider as established the mathematical law which determines the intensity of the polarised pencil, whatever be the nature of the body which reflects it, whatever be the angle at which it is incident, whatever be the number of reflections which it suffers, and whether these reflections are all made from one substance, or partly from one substance and partly from another.

"Let us suppose that a beam of common light composed of two portions A, B (fig. 168) polarised + 45° and — 45° to the plane of reflection, is incident on a plate of glass at such an angle that the reflected pencil composed of C and D has its planes of polarisation inclined at an angle φ to the plane MN. When a rhomb of calcareous spar has its principal section in the plane MN, it will divide the image C into an extraordinary pencil E and an ordinary one F; and the same will take place with D, G being its extraordinary, and H its ordinary image. If we represent the whole of the reflected pencil, or C + D, by 1, then $C = \frac{1}{2}$, $D = \frac{1}{2}$, $E + F = 1$, and $G + H = 1$. But since the planes of polarisation of C and D are each inclined φ degrees to the principal section of the rhomb, the intensity of the light of the doubly-refracted pencils will be as $\sin.^2 \varphi : \cos.^2 \varphi$; that is, the intensity of E will be $\frac{1}{2} \sin.^2 \varphi$, and that of F, $\frac{1}{2} \cos.^2 \varphi$. Hence it follows that the difference of these pencils, or $\frac{1}{2} \sin.^2 \varphi - \frac{1}{2} \cos.^2 \varphi$, will express the quantity of light which has passed from the extraordinary image E into the ordinary one F; that is, the quantity of light apparently polarised in the plane of reflection MN. But as the same is true of the pencil D, we have $2 (\frac{1}{2} \sin.^2 \varphi - \frac{1}{2} \cos.^2 \varphi)$ or $\sin.^2 \varphi - \cos.^2 \varphi$ for the whole of the polarised light in a pencil of common light C + D. Hence, since $\sin.^2 \varphi + \cos.^2 \varphi = 1$, and $\cos.^2 \varphi = 1 - \sin.^2 \varphi$, we have for the whole quantity of polarised light

Fig. 168.



$$Q = 1 - 2 \sin.^2 \varphi.$$

$$\text{But } \tan. \varphi = \tan. x \frac{\cos. (i + i')}{\cos. (i - i')}$$

$$\text{And as } \tan.^2 \varphi = \frac{\sin.^2 \varphi}{\cos.^2 \varphi}, \text{ and } \sin.^2 \varphi + \cos.^2 \varphi = 1,$$

we have the quotient and the sum of the quantities $\sin.^2 \varphi$ and $\cos.^2 \varphi$, by which we obtain

[1] Phil. Trans. 1830, p. 71.

Polarization.

$$\sin.^2\varphi = \frac{1}{1 + \left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}$$

$$= \frac{\left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}{1 + \left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}$$

That is, $$Q = 1 - 2\frac{\left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}{1 + \left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}.$$

"As the quantity of reflected light is here supposed to be 1, we may obtain an expression of Q in terms of the incident light, by adopting the formula of Fresnel for the intensity of a reflected ray. Thus,

$$Q = \tfrac{1}{2}\left(\frac{\sin.^2(i-i')}{\sin.^2(i+i')} + \frac{\tan.^2(i-i')}{\tan.^2(i+i')}\right) \times \left(1 - 2\frac{\left(\frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}{1 + \left(\frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}\right).$$

"As $\tan. x = 1$ in common light, it is omitted in the preceding formula.

"This formula may be adapted to partially polarised rays, that is, to light reflected at any angle different from the angle of maximum polarisation, provided we can obtain an expression for the quantity of reflected light.

"M. Fresnel's general formula has been adapted to this species of rays, by considering them as consisting of a quantity a of light completely polarised in a plane making the angle x with that of incidence, and of another quantity $1 - a$ in the state of natural light. Upon this principle it becomes

$$1 = \frac{\sin.^2(i-i')}{\sin.^2(i+i')} \cdot \frac{1 + a\cos.^2 x}{2} + \frac{\tan.^2(i-i')}{\tan.^2(i-i')} \cdot \frac{1 - a\cos.^2 x}{2}.$$

"But as we have proved that partially polarised rays are rays whose planes of polarisation form an angle of $2x$ with one another as already explained, x being greater or less than 45°, we obtain a simpler expression for the intensity of the reflected pencil, viz. the very same as that for polarised light.

$$1 = \frac{\sin.^2(i-i')}{\sin.^2(i+i')}\cos.^2 x + \frac{\tan.^2(i-i')}{\tan.^2(i+i')}\sin.^2 x.$$

Hence we have

$$Q = \left(\frac{\sin.^2(i-i')}{\sin.^2(i+i')}\cos.^2 x + \frac{\tan.^2(i-i')}{\tan.^2(i+i')}\sin.^2 x\right), \left(1 - 2\frac{\left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}{+\left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}\right).$$

"This formula is equally applicable to a single pencil of polarised light of the same intensity as the pencil of partially polarised light. In all these cases it expresses the quantity of light really or apparently polarised in the plane of reflection.

"In order to show the quantity of light polarised at different angles of incidence, I have computed the following table for common light, and suited to glass in which $m = 1{\cdot}525$.

Angle of Incidence i.	Angle of Refraction i'.	Inclination of Plane of Polarisation to Plane of Reflection, φ.	Quantity of Light Reflected out of 1000 Rays.	Quantity of Polarised Light Q.	Ratio of Polarised to Reflected Light.
0° 0′	0° 0′	45° 0′	43·23	0	0
10 0	6 32	43 51	43·39	1·74	0·04000
20 0	12 58	40 13	43·41	7·22	0·16618
25 0	16 5	37 21	43·64	11 6	0·26388
30 0	19 8½	33 40	44·78	17·25	0·3853
35 0	22 6	29 8	46·33	24·37	0·5260
40 0	24 56	23 41	49·10	33·25	0·6773
45 0	27 37½	17 22½	53·66	44 09	0·82167
50 0	30 9	10 18	61·36	57·36	0·9360
56 45	33 15	0 0	79·5	79·5	1·000
60 0	34 36	5 4½	93·31	91·6	0·9628
65 0	36 28	12 45	124·86	112·7	0·90258
70 0	38 2	18 32	162·67	129·80	0·79794
75 0	39 18	26 52	257·26	152·34	0·59154
78 0	39 54	30 44	329·95	457·67	0·47786
79 0	40 4	31 59	359 27	157·69	0·43892
80 0	40 13	33 13	391·7	156 6	0·40000
82 44	40 35	36 22	499·44	145·4	0·29112
84 0	40 42	38 2	560·32	134·93	0·2408
85 0	40 47	39 12	616·28	123·75	0·2008
86 0	40 51	40 22·7	676·26	108·67	0·16068
87 0	40 54	41 32	744·11	89·83	0·12072
88 0	40 57½	42 42	819·9	65·9	0·0804
89 0	40 58	43 51	904·81	36·32	0·04014
90 0	40 58	45 0	1000·0	0	0·0000

"As the preceding formula is deduced from principles which have been either established by experiment or confirmed by it, it may be expected to harmonize with the results of observation. At all the limits where the pencil is either wholly polarised or not polarised at all, it of course corresponds with experiment; but though, in so far as I know, there have been no absolute measures taken of the quantity of polarised light at different incidences, yet we are fortunately in possession of a set of experiments by M. Arago, who has ascertained the angles above and below the polarising angle at which glass and water polarise the same proportion of light. In no case has he measured the absolute quantity of the polarised rays: but the comparison of the values of Q at those angles at which he found them in equal proportions, will afford a test of the accuracy of the formula. This comparison is shown in the following table, in which column 1 contains the angles at which the reflecting surface polarises equal proportions of light; column 2 the values of φ, or the inclination of the planes of polarisation; and column 3 the intensities of the polarised light computed from the formula.

		Angles of Incidence.	Inclination of Planes of Polarisation to MN, or φ.	Proportion of Polarised Light, or Q.
Glass:	No. 1.	82° 48′	37° 33′	·2572
		24 18	37 21	·2637
	No. 2.	82 5	36 47	·2828
		26 6	36 0	·3090
	No. 3.	78 20	32 38	·4186
		29 42	33 1	·4064
Water:	No. 4.	86 31	41 54	·1080
		16 12	41 27	·1236

"The agreement of the formula with experiments made with as great accuracy as the subject will admit, must be allowed to be very satisfactory. The differences are within the limits of the errors of observation, as appears from the following table:

		Deviations from Experiment.	Part of the whole Light.
Glass:	No. 1.	0·0065	$\frac{1}{154}$
	No. 2.	0·0262	$\frac{1}{38}$
	No. 3.	0·0122	$\frac{1}{82}$
Water:	No. 4.	0·0156	$\frac{1}{64}$

"M. Arago has concluded, from the experiments above stated, that equal proportions of light are polarised at equal

Polarization. angular distances from the angle of complete polarisation. Thus, in glass No. 1, the mean of 82° 48′ and 24° 18′ is 53° 33′, which does not differ widely from the maximum polarising angle, or 55°, which M. Arago considers as the maximum polarising angle of the glass.[1] In order to compare this principle with the formula, I found, that in water No. 4, the angle which polarises almost exactly the same proportion of light as the angle of 86° 31′, is 15° 10′, the value of φ being 41° 54′ at both these angles; but the mean of these is 50° 50′ in place of 53° 11′, so that the rule of M. Arago cannot be regarded as correct, and cannot therefore be employed, as he proposes, to determine the angle of complete polarisation."[2] (*Phil. Trans.* 1830.)

4. *On the Law of the Polarisation of Light by successive Reflections.*

We come now to show the application of the preceding law of intensity to the phenomena of the polarisation of light by successive reflections.

"When a pencil of common light," says Sir David Brewster,[3] "has been reflected from a transparent surface, at an angle of 61° 3′, for example, it has experienced such a physical change that its planes of polarisation form an angle of 6° 45′ each with the plane of reflection. When it is incident on another similar surface at the same angle, it is no longer common light, in which $x = 45°$, but it is partially polarised light, in which $x = 6° 45'$. In computing, therefore, the effect of the second reflection, we must take the general formula $\tan. \varphi = \tan. x \left(\frac{\cos.(i+i')}{\cos.(i-i')}\right)$; but as the value of x is always in the same ratio to the value of φ, however great be the number of reflections, we have $\tan. \theta = \tan.^n \varphi$ for the inclination θ to the plane of reflection produced by any number of reflections n, φ being the inclination for one reflection. Hence, when θ is given by observation, we have $\tan. \varphi = \sqrt[n]{\theta}$. The formula for any number n of reflections is therefore $\tan. \theta = \left(\frac{\cos.(i+i')}{\cos.(i+i')}\right)^n$. It is evident that θ never can become equal to 0°; that is, that the pencil cannot be so completely polarised by any number of reflections at angles different from the polarising angle, as it is by a single reflection at the polarising angle; but we shall see that the polarisation is sensibly complete, in consequence of the near approximation of θ to 0°.

"I found, for example, that light was polarised by two reflections from glass at an angle of 61° 3′, and 60° 28′ by another observation. Now, in these cases, we have

	θ after 1st Reflection.	θ after 2d Reflection.	Quantity of Unpolarised Light.
two reflections at 61°	3′	6° 45′	0·00037
	60 28	5 38	0 33 0·00018

The quantity of unpolarised light is here so small as to be quite unappreciable with ordinary lights.

"In like manner, I found that light was completely polarised by five reflections at 70°. Hence, by the formula, we have

	Values of θ.	Unpolarised Light.
1 reflection at 70°	20° 0′	0·23392
2	7 32	0·03432
3	2 45	0·00460
4	1 0	0·00060
5	0 22	0·00008

The quantity of unpolarised light is here also unappreciable after the fifth reflection. Polarization.

In another experiment it was found that light was wholly polarised by the separating surface of glass and water at the following angles:

	Values of θ.	Unpolarised Light.
By 2 reflections at 44° 51′	0° 56′	0·0005
By 3	42 27	0 26 0·0001

"In all these cases the successive reflections were made at the same angle; but the formula is equally applicable to reflections at different angles,—

"1. When both the angles are greater than the polarising angle,—

	θ.	Unpolarised Light.
1 reflection at 58° 2′, and 1 at 67° 2′	0° 34′	0·0002

"2. When one of the angles is above and the other below the polarising angle,—

	θ.	Unpolarised Light.
1 reflection at 53°, and 1 at 58° 2′	0° 12′	0·000024

This experiment requires a very intense light; for I find in my journal that the light of a candle is polarised at 53° and 78°.

"In reflections at different angles, the formula becomes $\tan. = \frac{\cos.(i+i')}{\cos.(i-i')} \times \frac{\cos.(\mathrm{I}+\mathrm{I}')}{\cos.(\mathrm{I}+\mathrm{I}')}$, I and i being the angles of incidence. In like manner, if a, b, c, d, e, &c. are the values of φ or θ for each reflection, or rather for each angle of incidence, we shall have the final angle, or $\tan. \theta = \tan. a \times \tan. b \times \tan. c \times \tan. d$, &c.

"It is scarcely necessary to inform the reader, that when a pencil of light reflected at 58° 2′ is said to be polarized by another reflection at 67° 2′, it only means, that this is the angle at which complete polarisation takes place in diminishing the angle gradually from 90° to 67° 2′, and that even this angle of 67° 2′ will vary with the intensity of the original pencil, with the opening of the pupil, and with the sensibility of the retina. But when it shall be determined experimentally at what value of φ, or rather at what value of Q, the light entirely disappears from the extraordinary image, we shall be able, by inverting the formula, to ascertain the exact number of reflections by which a given pencil of light shall be wholly polarised.

"As the value of Q depends on the relation of i and i', that is, on the index of refraction, and as this index varies for the different colours of the spectrum, it is obvious that Q will have different values for these different colours. The consequence of this must be, that in bodies of high dispersive powers, the unpolarised light which remains in the extraordinary image, and also the light which forms the ordinary image, must be coloured at all incidences; the colours being most distinct near the maximum polarising angle. This necessary result of the formula was found to be experimentally true in oil of cassia, and various highly dispersive bodies. In realgar, for example, φ is $= 0$ at an angle of 69° 0′ for blue light, at 68° 37′ for green light, and at 66° 49′ for red light. Hence there can be no angle of complete polarisation for white light, which was also found to be the case by experiment; and as Q must at different angles of incidence have different values for the different rays, the unpolarised light must be composed of a certain portion of each different colour, which may be easily determined by the formula.

"Such are the laws which regulate the polarisation of

[1] Hence we have assumed $m = 1{\cdot}428$, the tangent of 55°, in the preceding calculations.
[2] It is obvious that the rule can only be true when $m = 1{\cdot}000$; so that its error increases with the refractive power.
[3] Phil. Trans. 1830, p. 80.

Polarization. light by reflection from the first surfaces of bodies that are not metallic. The very same laws are applicable to their second surfaces, provided that the incident light has not suffered previous or subsequent refraction from the first surface. The sine of the angle at which φ or Q has a certain value by reflection from the second surface, is to the sine of the angle at which they have the same value at the first surface, as unity is to the index of refraction. Hence φ and Q may be determined by the preceding formulæ after any number of reflections, even if some of the reflections are made from the first surface of one body and the second surface of another."

Sect. III.—*On the Polarisation of Light by Refraction.*

We have already seen that the polarisation of light by refraction was discovered by independent observations by Malus, Biot, and Brewster; but the priority of discovery belongs to Malus, who, from various observations, arrived at the following conclusion: "When a ray of light falls upon a plate of glass at an angle of 54° 35′, all the light which it reflects is polarised in one direction. The light which traverses the glass is composed, 1*st*, of a quantity of light polarised in a direction opposite to that which is reflected, and proportional to it; and, 2*dly*, of another portion not modified, and which preserves the character of direct light."

Sir David Brewster made analogous experiments with thin films of glass, films of mica, folds of gold-beaters' skin, and films of gold leaf; but he occupied himself chiefly in determining the law of the phenomena depending on the number of plates through which the light was transmitted, and found *that the number of plates which polarise a maximum of light by transmission at different angles of incidence, are to one another as the co-tangents of the angles of incidence.*

In determining this law, our author employed forty-seven plates of crown-glass, each about three inches long and one broad, and with these he obtained the following results:—

Number of Plates in each Parcel.	Angles of Incidence at which Light is Polarised, by Calculation.	Angles of Incidence at which Light is Polarised, by Experiment.	Differences between the Calculated and Observed Angles.
8	79° 11′	78° 52′ [1]	0 19′ —
10	76 33	76 24	0 9 —
12	74 0	74 2	0 2 +
14	71 30	72 15	0 45 +
16	69 4	69 40	0 36 +
18	66 43	66 43	0 0
21	63 21	63 39	0 18 +
24	60 8	61 0	0 52 +
27	57 10	56 58	0 12 —
29	55 16	54 50	0 26 —
31	53 28	53 16	0 12 —
33	51 44	51 0	0 44 —
35	50 5	50 23	0 18 +
39	47 1	46 50	0 11 —
41	45 35	45 49	0 14 +
44	43 34	44 0	0 26 +
47	41 41	42 0	0 19 +
100	22 42		
200	11 49		
500	4 47		
1,000	2 24		
2,000	1 12		
4,000	0 36		
14,000	0 1		
8,640,000	0 0 1″		

[1] This result was obtained by a parcel of plates of parallel glass.

If n, n', therefore, represent the number of plates in any two parcels, and φ, φ the angles at which the pencil was polarised, we have Polarization.

$$n : n' = \text{cotan. } \varphi : \text{cotan. } \varphi,' \text{ and}$$
$$n \times \text{tan. } \varphi = n' \times \text{tan. } \varphi'.$$

That is, the *number of plates in any parcel, multiplied by the tangent of the angle at which it polarises light, is a constant quantity.* From a great number of observations made with a parcel of eighteen plates, our author found the constant quantity for crown-glass to be 41·84 when the light was that of a good wax-candle placed at the distance of about twelve feet, so that we have

$$\text{tan. } \varphi = \frac{41{\cdot}84}{n};$$

that is, divide the constant quantity by any given number of plates, and the quotient will be the natural tangent of the angle at which that number will polarise a pencil of light.

In this way the *second* column of the table, which differs very little from the observed column, was computed.

From these experiments our author drew the same conclusion as in the case of reflection, respecting the state of what Malus calls the unpolarised light, namely, that it had suffered a physical change; and he also showed that light could be polarised by successive refractions, each refraction bringing it gradually nearer and nearer to the state of complete polarisation.

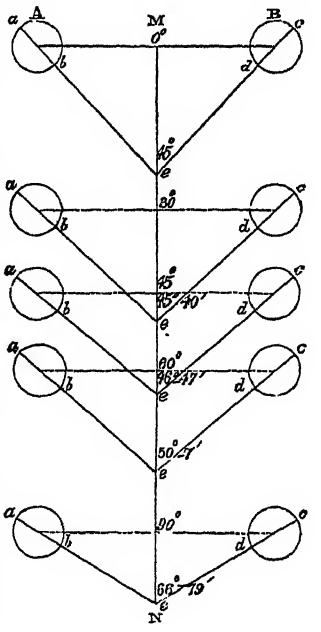
1. *On the Motion of the Planes of Polarisation by Refraction.*

The first, and we believe the only, experiments that have been made on this subject, were those of Sir David Brewster;[1] and we shall therefore give an account of his researches in his own words, abridging it as much as possible.

"If we take a plate of glass, deviating so slightly from parallelism between its faces as to throw aside from the direct transmitted image of a luminous body the faint images formed by reflection between its inner surfaces, we shall obtain, even at the greatest obliquities, a pencil of light free of all admixture of reflected light.

"Let this plate be placed upon a divided circle, so that we can observe through it two luminous discs of polarised light A, B (fig. 169) formed by double refraction, and having their planes of polarisation inclined + 45° and — 45° to the plane of refraction. At a perpendicular incidence, the inclination of the planes of polarisation will suffer no change; but at an incidence of 30° they will be turned round 40′, so that their inclination to MN or the angle *aec* will be 45° 40′. At 45° their inclination will be 46° 47′. At 60° it will be 50° 7′; and it will increase gradually to 90°, where it becomes 66° 19′. Hence the maximum change produced by a single plate of glass upon the planes of polarisation is 66° 19′ — 45° = 21° 19′, an effect exactly equal to

Fig. 169.



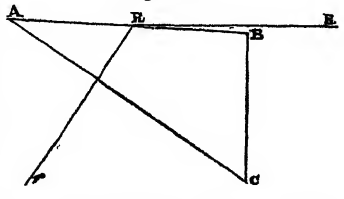
[1] Phil. Trans. 1830, p. 133.

Polarization. what is produced by reflection at angles of 39° or 70°. It is remarkable, however, *that this change is made in the opposite direction, the planes of polarisation now approaching to coincidence in a plane at right angles to that of reflection;* a difference which might have been expected from the opposite character of the resulting polarisation.

"In this experiment the action of the two surfaces is developed in succession, so that we cannot deduce from the maximum rotation of 21° 19′, the real action of the first, or of a single surface, which must be obviously more than half of the action of the two surfaces, because the planes of polarisation have been widened before they undergo the action of the second surface.

"In order to obtain the rotation due to a single surface, I took a prism of glass ABC, having such an angle BAC, that a ray RR, incident as obliquely as possible, should emerge in a direction Rr perpendicular to the surface AC. I took care that this prism was well annealed, and I caused the refraction to be performed as near as possible to the vertex A, where the glass was thinnest, and consequently most free from the influence of any polarising structure. In this way I obtained the following measures.

Fig. 170.



Glass.

Angles of Incidence.	Inclination of Planes *ab*, *cd*, to the Plane of Reflection.	Rotation of Plane for one Surface.
87° 38′	54° 15′	9° 15′
54 50	47 25	2 25
32 20	45 22	0 22

"I next made the following experiments with two kinds of glass, the one a piece of parallel plate-glass, and the other a piece of very thin crown. The latter had the advantage of separating the reflected from the transmitted light.

Plate Glass.			*Crown Glass.*	
Incidence.	Inclination.	Rotation for two Surfaces.	Inclination.	Rotation for two Surfaces.
0°	45° 0′	0° 0′	45° 0′	0° 0′
40	47 28	2 28	47 18	2 18
55	49 35	4 35	49 19	4 19
67	52 53	7 53	58 16	7 16
80	58 53	13 53	58 42	13 42
86½	61 16	16 16	61 0	16 0

"In order to ascertain the influence of refractive power, I stretched a film of soapy water across a rectangular frame of copper wire, and obtained the following measures:

Water.

Incidence.	Inclination.	Rotation.
85°	54° 17′	9° 17′

Metalline Glass.

0	45 0	0 0
20	45 42	0 42
30	46 50	1 50
40	48 0	3 0
55	51 12	6 12
80	62 32	17 32

"From a comparison of these results, it is manifest that *the rotation increases with the refractive power.*

"In examining the effects produced at different incidences, it is obvious that the rotation R varies with the deviation of the refracted ray; that is, with $i - i'$. Hence I have been led to express the inclination φ of the planes of polarisation to the plane of refraction and the rotation by the formulæ

$$\cot.\ \varphi = \cos.\ (i - i'), \qquad R = \varphi - 45°.$$

"This formula represents the experiments so accurately, that when the rhomb of calcareous spar is set to the calculated angle of inclination, the extraordinary image is completely invisible. Polarisation.

"The above expression is of course suited only to the case where the inclination x of the planes of polarisation *ab*, *cd* (fig. 139), is 45°; but when this is not the case, the general expression is

$$\cot.\ \theta = \cot.\ x \cos.\ (i - i').$$

"When the light passes through a second surface, as in a single plate of glass, the value of x for the second surface is evidently the value of φ after the first refraction; or, in general, calling θ the inclination after any number n of refractions, and φ the inclination after one refraction,

$$\cot.\ \theta = (\cot.\ \varphi)^n.$$

"When θ is given by observation we have

$$\cot.\ \varphi = \sqrt[n]{\cot.\ \theta}.$$

"The general formula for any inclination x and any number n of refractions is

$$\cot.\ \theta = \big(\cot.\ x \cos.\ (i - i')\big)^n, \text{ and}$$

$$\cot.\ \varphi = \sqrt[n]{\cot.\ x \cos.\ (i - i')}.$$

"And when $x = 45°$ and $\cot.\ x = 1$, as in common light,

$$\cot.\ \theta = \big(\cos.\ (i - i')\big)^n,$$

$$\cot.\ \varphi = \sqrt[n]{\cos.\ (i - i')}.$$

"As the term $\big(\cos.\ (i - i')\big)^n$ can never become equal to 0, the planes of polarisation can never be brought into a state of coincidence in a plane perpendicular to that of reflection.

"In order to compare the formula with experiment, I took a plate of well-annealed glass, which at all incidences separates the reflected from the transmitted rays, and in which m was nearly 1·510, and I obtained the following results:

Angles of Incidence.	Angles of Refraction.	Rotation observed.	Inclination observed.	Inclination calculated.	Difference.
0°	0° 0′	0° 0′	45° 0′	45° 0′	
10	6 36½	0 13	45 13	45 6	+0° 7′
20	13 5	0 27	45 27	45 25	+0 2
25	16 15	0 32	45 32	45 40	—0 8
30	19 20	0 40	45 40	46 0	—0 20
35	22 19	1 12	46 12	46 25	—0 13
40	25 10	1 30	46 30	46 56	—0 26
45	27 55	1 42	46 47	47 34	+0 47
50	30 29	2 48	47 42	48 24	—0 42
55	33 52	3 54	48 54	48 59	—0 5
60	35 0	5 7	50 7	50 36	—0 29
65	36 53	6 48	51 48	52 7	—0 19
70	38 29	8 7	53 7	53 59	—0 52
75	39 45	9 55	54 55	56 18	—1 23
80	40 42	12 10	57 10	59 5	—1 55
85	41 19	15 45	60 45	62 24	—1 39
86	41 21	16 39	61 39	63 9	—1 30
90	41 28			66 19	

"The last column but one of the table was calculated by the formula

$$\cot.\ \theta = \cos.\ \big(\cos.\ (i - i')\big)^2,$$

n being in this case 2. The errors, however, being almost all negative, I suspected that there was an error of adjustment in the apparatus; and upon repeating the experiment at 80°, the point of maximum error, I found that the inclination was fully 58° 40′, giving a difference only of 25 in place of 1° 55′.

"In these experiments $x = 45°$ and $\cot.\ x = 1$; but in order to try the general formula when x varied from 0° in 90°, I took the case where the angle of incidence was 80°,

Polarization. and $\varphi = 58° 40'$ when $x = 45°$. The following were the results.

Values of x.	Inclination observed.	Inclination calculated.	Difference.
0°	0° 0′	0° 0′	0° 0′
2½	7 10	7 20	— 0 10
5	9 40	8 19	+ 1 21
10	17 10	16 25	+ 0 45
15	24 42	24 6	+ 0 36
20	32 30	31 19	+ 1 11
25	39 15	37 54	+ 1 21
30	44 10	43 57	+ 0 13
35	49 38	49 28	+ 0 10
40	54 36	54 31	+ 0 5
45	58 40	59 5	— 0 25
50	63 10	63 19	— 0 9
55	66 58	67 15	— 0 17
60	70 18	70 56	— 0 38
65	74 8	74 24	— 0 16
70	76 56	77 42	— 0 46
75	79 20	80 53	— 1 33
80	83 23	83 58	— 0 35
85	86 23	86 0	+ 0 23
90	90 0	90 0	0 0

"The last column but one was calculated by the formula $\cot. \theta = \cot. x \,.\, (\cot. 58° 40')^2$.

"In determining the quantity of polarised light in the refracted pencil, we must follow the method already explained for the reflected ray, *mutatis mutandis*. The principal section of the analysing rhomb being now supposed to be placed in a plane perpendicular to the plane of reflection, the quantity of light Q′ polarised in that plane will be

$$Q' = 1 - 2 \cos.^2 \varphi,$$

the quantity of transmitted light being unity. But

$$\cot. \varphi = \cot. x \cos. (i - i'),$$

and as $\cot. \varphi = \frac{\cos.^2 \varphi}{\sin.^2 \varphi}$, and $\sin.^2 \varphi + \cos.^2 \varphi = 1$, we have the quotient and the sum of $\sin.^2 \varphi$ and $\cos.^2 \varphi$ to find them.

$$\text{Hence } \cos.^2 \varphi = \frac{(\cot. x \cos. (i-i'))^2}{1 + (\cot. x \cos. (i-i'))^2};$$

and by substituting this for $\cos.^2 \varphi$ in the former equation, it becomes

$$Q' = 1 - 2 \frac{(\cot. x \cos. (i-i'))^2}{1 + (\cot. x. \cos. (i-i'))^2}.$$

"Now since, by Fresnel's formula, the quantity of reflected light is

$$R = \tfrac{1}{2} \left(\frac{\sin.^2 (i-i')}{\sin.^2 (i+i')} + \frac{\tan.^2 (i-i')}{\tan.^2 (i+i')} \right),$$

the quantity of transmitted light T will be

$$T = 1 - \tfrac{1}{2} \left(\frac{\sin.^2 (i-i')}{\sin.^2 (i+i')} + \frac{\tan.^2 (i-i')}{\tan.^2 (i+i')} \right).$$

$$\text{Hence } Q' = \left(1 - \tfrac{1}{2} \left(\frac{\sin.^2 (i-i')}{\sin.^2 (i+i')} + \frac{\tan.^2 (i-i')}{\tan.^2 (i+i')} \right) \right) \left(1 - 2 \frac{(\cos. (i-i'))^2}{1 + (\cos. (i-i'))^2} \right).$$

"This formula is applicable to common light, in which $\cot. x = 1$ disappears from the equation; but, on the same principles which we have explained in a preceding paper, it becomes for partially polarised rays and for polarised light,

$$Q' = \left(1 - \tfrac{1}{2} \left(\frac{\sin.^2 (i-i')}{\sin.^2 (i+i')} \cos.^2 x + \frac{\tan.^2 (i-i')}{\tan.^2 (i+i')} \sin.^2 x \right) \right) \left(1 - 2 \frac{(\cot. x \cos. (i-i'))^2}{1 + (\cot. x \cos. (i-i'))^2} \right).$$

"In all these cases the formula expresses the quantity of light really or apparently polarised in the plane of refraction. Polarization.

"As the planes of polarisation of a pencil polarised + 45° and — 45° cannot be brought into a state of coincidence by refraction, the quantity of light polarised by refraction can never be mathematically equal to the whole of the transmitted pencil, however numerous be the refractions which it undergoes; or, what is the same thing, refraction cannot produce rays truly polarised, that is, with their planes of polarisation parallel."

2. *On the partial Polarisation of Light by one or more Refractions.*

"The analysis given in the preceding paragraphs, of the changes produced on common light, considered as represented by two oppositely polarised pencils, furnishes us with the same conclusions respecting the partial polarisation of light by refraction which we have already deduced respecting the partial polarisation of light by reflection. Each refracting surface produces a change in the position of the planes of polarisation, and consequently a physical change upon the transmitted pencil by which it has approached to the state of complete polarisation.

"This position I shall illustrate by applying the formula to the experiments in a preceding page.

"According to the first of these, the light of a wax-candle at the distance of ten or twelve feet is wholly polarised by eight plates or sixteen surfaces of parallel plate-glass at an angle of 78° 52′. Now I have ascertained that a pencil of light of this intensity will disappear from the extraordinary image, or appear to be completely polarised, provided its planes of polarisation do not form an angle of less than 88¾° with the plane of refraction for a moderate number of plates, or 88½° for a considerable number of plates, the difference arising from the great diminution of the light in passing through the substance of the glass. In the present case the formula gives

$$\cot. \theta = \left(\cos. (i - i') \right)^{16} \text{ and } \theta = 88° 50';$$

so that the light should appear to be completely polarised, as it was found to be.

"At an angle of 61° 0′ the pencil was polarised by twenty-four plates or forty-eight surfaces. Here

$$\cot. \theta = \left(\cos. (i - i') \right)^{48} = 89° 36'.$$

"At an angle of 43° 34′ the light was polarised by forty-seven plates or ninety-four surfaces. Here

$$\cot. \theta = \left(\cos. (i - i') \right)^{94} \text{ and } \theta = 88° 27'.$$

"It is needless to carry this comparison any further; but it may be interesting to ascertain by the formula the smallest number of refractions which will produce complete polarisation. In this case the angle of incidence must be 90°.

"Hence, $\varphi = 56° 29'$ and $\left(\cos. (i - i') \right)^9$ gives 88° 36′, and $\left(\cos. (i - i') \right)^{10}$ 89° 4′; that is, the polarisation will be nearly complete by the most oblique transmission through four and a half plates or nine surfaces, and will be perfectly complete through five plates or ten surfaces."

Sect. IV.—*Comparison of the Laws of Intensity for Light polarised by Reflection and Refraction.*

"Having obtained formulæ for the quantity of light polarised by refraction and reflection, it becomes a point of great importance to compare the results which they furnish. Calling R the reflected light, these formulæ become

Polarization.

$$Q = R\left(1 - 2\frac{\left(\frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}{1+\left(\frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}\right), \text{ and}$$

$$Q' = 1 - R\left(1 - 2\frac{(\cos.(i-i'))^2}{\varphi + (\cos.(i-i'))^2}\right).$$

"But these two quantities are equal, and hence we obtain the important general law, that,—*At the first surface of all bodies, and at all angles of incidence, the quantity of light polarised by refraction is equal to the quantity polarised by reflection. I have said 'of all bodies,' because the law is equally applicable to the surfaces of crystallized and metallic bodies, though the action of their first surface is masked or modified by other causes.*

"It is obvious from the formula that there must be some angle of incidence where R = 1 — R, or the reflected equal to the transmitted light. When this takes place, we have $\sin.^2 \varphi = \cos.^2 \varphi'$; that is,

"*The reflected is equal to the transmitted light, when the inclination of the planes of polarisation of the reflected pencil to the plane of reflection, is the complement of the inclination of the planes of polarisation of the refracted pencil to the same plane;* or, if we refer the inclination of the planes to the two rectangular planes into which the planes of polarisation are brought,—*The reflected will be equal to the transmitted light when the inclination of the planes of polarisation of the reflected pencil to the plane of reflection is equal to the inclination of the plane of polarisation of the refracted pencil to a plane perpendicular to the plane of reflection.*

"In the following table, the inclination of the planes of polarisation of the reflected and the refracted pencil, and the quantities of light reflected, transmitted, and polarised, at all angles of incidence upon glass, *m* being equal to 1·525, and the incident light = 1000, are given:

Angles of Incidence, *i*.	Angles of Refraction, *i'*.	Inclination of Plane of Polarisation of the Reflected Light, φ'.	Inclination of Plane of Polarisation of the Refracted Light, φ.	Quantity of Light Reflected, R.	Quantity of Light Transmitted, 1 — R.	Quantity of Light Polarised, Q.
0° 0′	0° 0′	45° 0′	45° 0′	43·23	956·77	0·
2 0	1 18⅔	44 57	45 0·7	43·26	956·74	0·07
10 0	6 32	43 51	45 3	43·39	956·61	1·73
20 0	12 58	40 13	45 13	43·41	956·59	7·22
25 0	16 5	37 21	45 21	43·64	956·36	11·6
30 0	19 8½	33 40	45 31	44·78	955·22	17·24
35 0	22 6	29 8	45 44	46·33	953·67	24·4
40 0	24 56	23 41	46 0	49·10	950·90	32·2
45 0	27 37½	17 22½	46 20	53·66	946·33	44·0
50 0	30 9	10 18	46 45	61·36	938·64	57·4
56 45	33 15	0 0	47 29	79·5	920·5	79 5
60 0	34 36	5 4½	47 54½	93·31	906 69	91·6
65 0	36 28	12 45	48 42	124·86	875·14	112·7
70 0	38 2	18 32	49 28	162·67	837·33	129·8
75 0	39 18	26 52	50 55	257·56	742·44	152 3
78 0	39 54	30 44	51 48	329·95	670·05	157·6
78 7	39 55	30 53	51 50	333·20	666·80	157·65
79 0	40 4	31 59	52 7	359·27	640·73	157 6
80 40	40 13	33 13	52 27½	391·7	608·3	156·7
82 4	40 35	36 22	53 26⅓	499 44	500·56	145·4
84 0	40 42	38 2	53 57	560·32	439·68	134·93
85 0	40 47	39 12	54 22	616·28	383·72	123·7
85 50⅔	40 50⅔	40 12	54 44	666·44	333·56	111·11
86 0	40 51	40 22.7/16	54 48	676·26	323·74	108·67
87 0	40 54	41 32	55 16	744·11	255·89	89·8
88 0	40 57½	41 23	55 43	819·9	180·1	65·9
89 0	40 58	43 51	56 14	904·81	95·19	36·3
90 0	40 58	45 0	56 29	1000·	.0·	0·

"It is obvious, from a consideration of the principle of the formula for reflected light, that the quantity of polarised light is nothing at 0°, because the force which polarises it is there a minimum. At the maximum polarising light, Q is only 79·5, because the glass is incapable of reflecting more light at that angle, otherwise more would have been polarised. The value of Q, then, rises to its maximum at 78° 7′, and descends to its minimum at 90°; but the polarising force has not increased from 56° 45′ to 78° 7′, as the value of φ' shows. It is only the quantity of reflected light that has increased which occasions a greater quantity of light to disappear from the extraordinary image of the analysing rhomb.

Polarization.

"The case, however, is different with the refracted light. The value of Q′ has one minimum at 0°, and another at 90°, while its maximum is at 78° 7′; while the force has its minimum at 0°, and its minimum at 90°, where its effect is a minimum only because there is no light to polarise. At the incidence of 78° 7′, where the quantities Q, Q′ reach their maxima, the reflected light is exactly one half of the transmitted light; $\sin.^2 \varphi' = \cos.^2 \varphi$ and tan. $\varphi' = \cos. \varphi$.

"At 85° 50′ 40″, where the transmitted light is one half of the reflected light, the deviation $(i - i') = 45°$, and the quantity of polarised light is one third of the transmitted light, one sixth of the reflected light, and one ninth of the incident light. $\sin.^2 \varphi' : \cos.^2 \varphi =$ reflected light: transmitted light, and cot. $\varphi = \sin.(i - i')$.

"At 45° we have $(i + i') + (i - i') = 90°$ and $\varphi' = (i - i')$, $\tan.(i - i') = \frac{\cos.(i+i')}{\cos.(i-i')}$, and $\tan.(i-i')^2 = \frac{(\sin.(i-i'))^2}{(\sin.(i+i'))^2}$.

"At 56° 45′, the polarising angle, the formula for reflected light becomes $R = \frac{1}{2}(\sin.^2(i - i'))^2$; but at this angle we have $i' = 90° - i$. Hence we obtain the following simple expression in terms of the angle of incidence, for the quantity of light reflected by all bodies at the polarising angle:

$$R = \tfrac{1}{2}(\cos. 2i)^2."$$

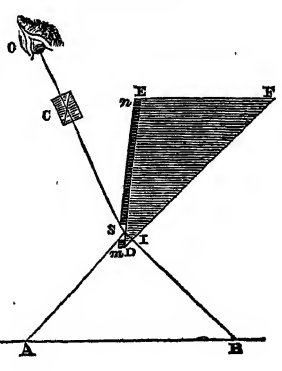
Sect. V.—*On the Action of Single Plates and Single Surfaces in polarising Light by Reflection and Refraction.*

In the article Polarisation of Light in this work, M. Arago has described an elegant experiment, from which he deduced the conclusion, that *the quantity of polarised light contained in the pencil transmitted by a transparent plate is exactly equal to the quantity of light polarised at right angles, which is found in the pencil reflected by the same plate.*

Now this law is true only at the maximum polarising angle, the two pencils being unequal at all other angles of incidence. The apparent equality observed by M. Arago seems to have arisen from other light being blended with the pencils. In order, therefore, to obtain the true law for single plates, we must determine it for a *single surface.*

In order to do this, Sir David Brewster employed a well-annealed prism of colourless glass, in place of a plate of glass, and he made the ray BI from a sheet of white paper BA enter the surface FD perpendicularly at I, while another ray AS was reflected to the eye from the surface ED of the prism. He then made the experiment with a doubly refracting prism C in the manner described by M. Arago, and obtained the law for *a single surface*, viz.

Fig. 171.



That the quantity of polarised light in the pencil re-

Polarization. *fracted by a transparent surface is exactly equal to the quantity in the pencil reflected by it.*

That is, what was supposed to be true of plates is true only of surfaces.

The action of a single plate on light, involving the combined action of three refractions and two reflections, without following the light beyond one internal reflection, is sufficiently complex, and has been analysed in the following manner by Sir David Brewster:—

He took a plate of glass of the form MN (fig. 172), having an oblique face M*d* cut upon one of its ends.

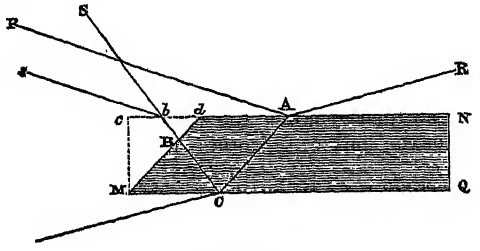


Fig. 172.

"A ray of light RA, polarized + 45° and − 45°, was made to fall upon it at A, at an angle of incidence of nearly 83°, so that the inclination of the planes of polarization of the reflected ray AP was about 36½°. Now the ray AC, after reflection in the direction CS, without any refraction at B, where it emerges perpendicularly to M*d*, would also have had the inclination of its planes of polarization equal to 36½° if there had been no intermediate refraction at A; but this refraction alone being capable of producing an inclination of 53°, or a rotation of 53° − 45° = 8°, and this rotation being in an opposite direction from that produced by the second reflection at C, the inclination of the planes of polarization for the ray CS is nearly 44½°, the reflection of C having brought back the ray AC almost exactly into the state of natural light.

"Without changing either the light or the angle, I cemented a prism M*cd* on the face M*d*, so that *cd* was parallel to *d*N, and I found that the second refraction at *b*, equal to that at A, changed the inclination of the planes of polarization to 53°; that is, the two refractive actions at A and *b* had overcome the action of reflection at C, and the pencil *bs* actually contained light polarized perpendicular to the plane of reflection.

"When the pencil RA is incident on the first surface at the polarizing angle or 56° 45′, the rotation produced by refraction at A is about 2°, or the inclination I = 45° + 2° = 47°; but the maximum action of the polarizing force at C is sufficient to make I = 0° whether x is 45° or 47°. Hence CB is completely polarized in the plane of reflection, and the refractive action at *b* is incapable of changing the plane of polarization when I = 0°; the reason is therefore obvious why the two rotations at A and *b*, of 2° each, produce no effect at the maximum polarizing angle.

"If we now call

φ = inclination to the plane of reflection produced by the first refraction at A,

φ' = inclination produced by the reflection at C.

φ'' = inclination produced by the second refraction at *b*,

We shall have

$$\cot \varphi = \cos (i - i'), \text{ or } \tan \varphi = \frac{1}{\cos (i-i')},$$

$$\tan \varphi' = \tan x \frac{\cos (i+i')}{\cos (i-i')} = \frac{\cos (i+i')}{(\cos (i-i'))^2},$$

$$\cot \varphi'' = \cot x \, (\cos (i-i')) = \frac{(\cos (i-i'))^3}{\cos (i+i')}.$$

"These formulæ are suited to common light, where x = 45°, but when x varies they become

$$\cot \varphi = \cot x \, (\cos (i-i')),$$

$$\tan \varphi' = \tan x \left(\frac{\cos (i+i')}{(\cos (i-i'))^2} \right),$$

$$\cot \varphi'' = \cot x \left(\frac{(\cos (i-i'))^3}{\cos (i+i')} \right).$$

Polarization.

"Resuming the formula for common light,—viz., $\cot \varphi = \frac{(\cos (i-i'))^3}{\cos (i+i')}$, it is obvious that when $(\cos (i-i'))^3 = \cos (i+i')$, $\cot \varphi'' = 1$, and $\varphi'' = 45°$; that is, the light is restored to common light.

"In glass where $m = 1{\cdot}525$ this effect takes place at 78° 7′, a little below 78° in diamond, and a little above 80° in water.

"At an angle below this φ becomes less than 45°, and the pencil contains light polarized in the plane of reflection; while at all greater angles φ is above 45°, and the pencil contains light polarized perpendicular to the plane of reflection. Hence we obtain the following curious law:—

"'*A pencil of light reflected from the second surfaces of transparent plates, and reaching the eye after two refractions and an intermediate reflection, contains, at all angles of incidence from* 0° *to the maximum polarizing angle, a portion of light polarized in the plane of reflection. Above the polarizing angle the part of the pencil polarized in the plane of reflection diminishes till* $\cos (i+i') = (\cos i - i'))^3$, *when it disappears, and the whole pencil has the character of common light. Above this last angle the pencil contains a quantity of light polarized perpendicular to the plane of reflection, which increases to a maximum, and then diminishes to zero at* 90°.'

"Let us now examine the state of the pencil CS′ after only one refraction and one reflection. Resuming the formula $\tan \varphi' = \frac{\cos (i+i')}{(\cos (i-i'))^2}$, it is evident that when $(\cos (i-i'))^2 = \cos (i+i')$, $\varphi' = 45°$, and the light restored to common light. This takes place in glass at an angle of 82° 44′. At all angles beneath this the pencil contains light polarized in the plane of reflection; but at all angles above it, the pencil contains light polarized perpendicular to the plane of reflection, the quantity increasing from 82° 44′ to its maximum, and returning to its minimum at 90°.

"Let us now apply the results of the preceding analysis to M. Arago's experiment. Suppose the angle of incidence to be 78° 7′, and let the light polarized by reflection at A (fig. 172) be = m, and that polarized by one reflection also = m. Then, since the pencil *bs* is common light, the polarized light in the whole reflected pencil AP, *bs*, is = m, whereas the light polarized by the two refractions is = $2m$; so that the experiment makes two quantities appear equal when the one is double that of the other. If the angle exceeds 78° 7′, the oppositely polarized light in the pencil *bs* will neutralize a portion of the polarized light in the pencil AP, and the ratio of the oppositely polarized rays which seem to be compensated in the experiment may be that of $3m$ or even $4m$ to 1.

"We may now obtain formulæ for computing the exact quantities of polarized light at any angle of incidence, either in the pencil CBS or *bs*.

"The primitive ray RA being common light, AC will not be in that state, but will have its planes of polarization turned round a quantity x by the refraction at A; so that $\cot x = \cos (i-i')$. Hence we must adopt for the measure of the light reflected at C the formula of Fresnel for polarized light whose plane of incidence forms an angle x with the plane of reflection. The intensity of AC being known from the formula for common light, we shall call it unity,

Polarization.

then the intensity I of the two pencils polarized $-x$ and $+x$ to the plane of reflection will be

$$I=\frac{\sin^2(i-i')}{\sin^2(i+i')}\cos^2 x+\frac{\tan^2(i-i')}{\tan^2(i+i')}\sin^2 x, \text{ and}$$

$$Q=I\left(1-2\,\frac{\left(\frac{\cos(i+i')}{(\cos(i-i'))^2}\right)^2}{+1\left(\frac{\cos(i+i')}{(\cos(i-i'))^2}\right)}\right).$$

"In like manner, if the intensity of CB = 1, we have

$$\tan x=\frac{\cos(i+i')}{(\cos(i-i'))^2},$$

and the intensity I of the transmitted pencil *bs*

$$I=1-\frac{\sin^2(i-i')}{\sin^2(i+i')}\cos^2 x+\frac{\tan^2(i-i')}{\tan^2(i+i')}\sin^2 x, \text{ and}$$

$$Q=\left(I\,1-2\,\frac{\left(\frac{(\cos(i-i'))^3}{\cos(i+i')}\right)^2}{1+\left(\frac{(\cos\ i-i')^3}{\cos(i+i')}\right)^2}\right).$$

"The following table, computed from the formulæ in the preceding page, shows the state of the planes of polarization of the three rays AC, CS, and *bs*.

Angle of Incidence on the First Surface.	Angle of Refraction at First Surface, and Angle of Incidence on Second Surface.	Inclination of Plane of Polarization of AC, fig. 172.	Inclination of Plane of Polarization of CS, fig. 172.	Inclination of Plane of Polarization of *bs*, fig 172.
0° 0′	0° 0′	45° 0′	45° 0′	45° 0′
32 0	20 33	45 34	32 20	32 51
40 0	25 10	45 58	24 12	24 56
45 0	27 55	46 17	17 49	18 38
56 30	33 30	47 22	0 0	0 0
67 0	37 34	48 57	18 20	20 50
70 0	38 30	49 33	23 34	27 6
75 0	39 46	50 45	32 22	37 48
78 37	40 29	51 49	38 10	44 59
79 0	40 33	51 56	38 49	45 46
80 0	40 42	52 16	40 27	47 46
83 0	41 5	53 21	44 39	53 40
86 30	41 23	54 47	50 58	60 13
90 0	41 58	56 29	56 29	66 19

Sect. VI.—On the Polarization of Light by Absorption and Dispersion.

Polarization by absorption, &c.

In the preceding section we have considered common light as consisting of two pencils of polarized light, having their planes of polarization at right angles to each other. The very same results would take place if we considered a beam of light as consisting of two sets of polarized rays, all those of one set having their planes of polarization in every possible direction, and of another set having their planes of polarization at right angles to those of the former.[1] In this view of the subject common light is polarized when it issues from the luminous body, and when we polarize it or decompose it by double refraction, or polarize it completely by reflection or refraction, we merely separate the one-half of it polarized + from the half polarized −. This effect its analogous to the decomposition of white light into is colours. All the colours exist in the sun's light, and they are merely separated by prismatic refraction, or by interference, or by absorption. Polarization.

Now common light may also be decomposed by dispersion and absorption; that is, if we can contrive any method of dispersing or absorbing *one of the two polarized pencils* of common light, we shall exhibit the other pencil in its state of natural polarization.

Crystals in which this effect is produced are called singly-polarizing or singly-refracting crystals. They were first observed and described by Sir David Brewster in the year 1812.[2] The first mineral in which he discovered this property was the *agate*, in which one of the pencils is dispersed into a nebulous mass of light, sometimes of the form of a crescent, so that the bright image was all polarized in one plane, like one of the pencils of Iceland spar. The mass of nebulous light, too, was always polarized in a plane perpendicular to that of the bright image. Agate.

The same author discovered a similar property in certain specimens of the *carbonate of barytes*, which exhibited several interesting phenomena[3] in thick crystals of mica,[4] and in mother-of-pearl,[5] and very curiously in oil of mace,[6] and other substances. The same property he found in various artificial crystals, but particularly in nitre. Carbonate of barytes.

Another very beautiful example of polarized nebulous images was observed by the same author in an artificial kind of nacre already referred to, in which there are three nebulous polarized images, with a bright image inclosed in the middle one of the three nebulous images.[7]

A similar property was discovered in 1815 in the *tourmaline*, nearly about the same time, by M. Biot and M. Seebeck, the priority belonging to the former. This crystal has double refraction, like all other crystals of the same class; but when it is cut by planes passing through the axis of the crystal, and has a certain thickness (about the 25th of an inch, but which varies in different specimens), it transmits only one of the pencils formed by double refraction. The pencil polarized in the plane of the principal section is absorbed, or somehow or other lost, while the one depolarized at right angles to that section is transmitted. If we take two such plates of tourmaline, and place them with their axes parallel, the unabsorbed pencil will be freely transmitted through both; but if we begin to turn one of them round, the light will become fainter and fainter, and the luminous object will vanish entirely when the axes are at right angles to each other. By continuing to turn, the image again appears, reaches its maximum when the axes are parallel, and then vanishes when the axes are at right angles. Tourmaline.

In all the singly-refracting and polarizing crystals above enumerated, the effects described arise from a certain degree of imperfection in the structure and combination of the elementary crystals, by which one of the polarized pencils is reflected or absorbed; but Sir David Brewster found that the same property may be communicated to any crystal, *merely by altering its superficial conformation.*

If we take a hexahedral prism of *nitrate of potash*, and observe a luminous object through two of its inclined surfaces that have a good natural or artificial polish, we shall perceive two distinct and perfectly-formed images. If we now roughen these two surfaces, and cement upon each of them a plate of glass by means of *balsam of capivi*, the character of the two images will be greatly changed. The image that has suffered the *greatest* refraction will be as *distinct* as before, but the other image will be either of a *faint reddish colour* or wholly invisible, according to the degree of roughness induced upon the refracting surfaces.

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[1] *Phil. Trans.* 1815, p. 149; ibid. 1830, p. 84.
[2] *Treatise on New Philosophical Instruments*, p. 329; see also *Phil. Trans.* 1813, p. 101: ibid. 1814, p. 188.
[3] *Edin. Trans.*, vol. vii., p. 289. [4] *Phil. Trans.* 1814, p. 225. [5] Ibid. 1814. [6] Ibid., pp. 27 and 38. [7] Ibid. 1836, p. 53.

Polarization.

When *oil of cassia* is used, the *least refractive image*, if visible before, will now be *completely extinguished.*

By substituting pure *alcohol*, or the *white of an egg*, instead of the balsam, the *least refracted image* will become *distinct*, and the *most refracted image* will be either a mass of *nebulous light*, or almost invisible.

In order to explain these phenomena, we must recollect that the index of refraction for the *ordinary* image of *nitre* is 1·511, and that of the *extraordinary* image 1·328. When the rough surface of the nitre is covered with balsam of capivi, which has nearly the same index of refraction as the ordinary image, the same effect is produced as if the rough surface had been polished for the ordinary rays. All the little pits or depressions in the rough surface being filled up with balsam, the ordinary rays suffer little or no refraction in penetrating the crystal, and therefore the image which they form will be as clear and distinct as in the first experiment. But since the index of refraction for the extraordinary image is much less than that of the balsam, the rays of which it is composed will not enter the crystal undisturbed, but will be scattered in the same manner as if its surface was rough, and had a refractive power corresponding to the difference between the index of refraction for the extraordinary ray, and the index of refraction for the balsam. When *water* or *alcohol* is substituted in room of the *balsam*, the effects now described are interchanged, the roughness being removed for the extraordinary rays by the application of a fluid of the same refractive density, while the rays that form the ordinary image are dispersed by the refractions which still exist at the rough surface of the crystal.

These effects will be better understood by supposing the crystal to consist of an extraordinary and an ordinary medium, arranged in alternate strata, or as water exists in wet hydrophanous opal. When the superficial polish of both these media is removed, the application of the *balsam* restores, as it were, the polish of the ordinary medium, without restoring that of the extraordinary medium; while the application of the *alcohol* restores the polish of the extraordinary medium without restoring that of the ordinary medium.

These results were repeatedly obtained with *calcareous spar*, *arragonite*, *nitre*, *carbonate of potash*, and other crystals (*Phil. Trans.*, 1819); and we have now before us a singly polarizing prism of *Iceland spar*, made nearly forty years ago, which answers all the common purposes of a plate of tourmaline or a parcel of glass plates.

Sect. VII.—On the Depolarization of Light, and the Colours of thin Crystallized Plates in Polarized Light.

The phenomena which we are about to describe are among the most splendid in optics. They were discovered by independent observation by M. Arago and Sir David Brewster, the priority of discovery belonging to M. Arago. The very same colours, indeed, as we shall presently see, had been observed by Huygens, Robison, Malus, and others, in Iceland spar; but they were not aware of their nature and origin.

There are *four* methods of exhibiting these colours, which may be used at pleasure, and each of which has its advantages.

First method of showing the phenomena.

1. If we take a plate of *agate* or *tourmaline*, or Herapath's *artificial tourmaline*,[1] or any other of the artificial singly-polarizing crystals already described, and having cut it into two parts, each of which is at least equal to the diameter of the pupil of the eye, though this is not absolutely requisite, fix each of them above an aperture in a piece of card or brass, so that no light passes at their edges. Let them be now placed at the distance of an inch or more, the one near the eye being capable of turning round the axis of vision; and let this last be turned into such a position that the light of the sky, or that of a flame enlarged by a lens placed near it, is no longer able to penetrate the second singly-refracting plate.

Polarization.

If we now introduce between the two plates of tourmaline, for example, a plate, either thick or thin, of any doubly-refracting substance, we shall observe very curious effects. If the plate is *thick*, such as one of sulphate of lime, the 30th of an inch and upwards, we shall find that the insertion of the plate has *revived*, as it were, the light which refused to pass through the second plate, and this light will be white. If we turn the sulphate of lime round, we shall find *four positions*, 90° from each other, in which the revived light is a maximum; and other four bisecting these, and also 90° from each other, in which the light entirely vanishes, as before the sulphate of lime had been introduced.

This property of reviving the light has been called the *depolarization of light*, because the sulphate of lime deprives the rays polarized by the first plate of that kind of polarization which prevented them from penetrating the second plate.

But if the plate is thin, between the 50th and 75th of an inch, we shall have precisely the same phenomena, with this difference only, that the restored light is brilliantly coloured. The colours vary in intensity, like the white light, disappearing in the positions 0°, 90°, 180°, and 270°, and reaching their maximum at 45°, 135°, 225°, and 315°. If we now turn the plate of tourmaline next the eye round 90°, so that the axes of the two plates are parallel, and the pencil polarized by the first freely transmitted by the second, and if we then introduce the same plate of sulphate of lime as before, we shall now find that in the *four* positions of it, —viz., 0°, 90°, 180°, and 270°, where no light or colours were formerly, nothing but white light is visible; but that at the positions 45°, 135°, 225°, and 315°, where the maxima of light and colour took place, we have the maxima of a colour *complementary* to that formerly seen, the intensity of this colour gradually increasing from nothing at 0°, reaching its maximum at 45°, again diminishing to 90°; and so on with the other quadrants. These colours are called the *colours of crystallized plates, or the colours of polarized light.*

In the preceding experiment with plates of tourmaline, we see only one of the two complementary colours, while the position of the tourmaline remains the same. The disadvantage of using the tourmalines is, that from their brown colour the brilliancy of the polarized colours is greatly injured; and the tourmalines therefore cannot be employed, either when we wish to have the most brilliant representations of the phenomena, or when it is necessary to study the exact tints developed.

But if we use the plates of *agate* or of roughened Iceland spar in the same manner, we shall not only have identically the same phenomena of colour in the bright and distinct image formed by the agate with a purer light; but we shall have the additional phenomenon of this bright coloured image placed in the middle of a *nebula* or haze of the *complementary* colour, so that we here see both the colours at the same time, and without any of the superadded brown colour imparted by the tourmaline. If the colour of the

[1] These *artificial tourmalines* are thin crystals of the sulphate of iodo-quinine, which are impervious to light when crossed at right angles. Dr Herapath has made them six-tenths of an inch in breadth.

Mortality, Law of.

TABLE VI.—*Exhibiting the Expectation of Life in Sweden and Finland, both according to Columns A and D of the preceding Table.*

Age.	A. More Correct.	D. Less Correct.	Age.	A. More Correct.	D. Less Correct.
	Expectation of Life.			Expectation of Life.	
0	39·385	30·863	50	18·651	18·159
5	50·014	45·719	55	15·550	15·384
10	47·629	44·361	60	12·598	12·562
15	43·809	41·019	65	9·933	9 978
20	39·980	37·531	70	7·497	7·536
25	36·330	34·299	75	5·665	5·752
30	32·684	30·983	80	4·165	4·259
35	29·063	27·650	85	3·232	3·361
40	25·495	24·382	90	2·357	2·770
45	22·066	21·294	95	1·700	1·167

TABLE VII.—*Exhibiting the Increase of the Total Pop. of Sweden and Finland, and the Decrease of the Absolute Number above 90 Years of Age, throughout the latter half of the Eighteenth Century.* Mortality, Law of.

In the Year	Total Pop. of Sweden and Finland.	Above 90 Years.	Who were born between the Years
1757	2,323,195	1609	1657 and 1667
1760	2,367,598	1574	1660 ... 1670
1763	2,446,394	1515	1663 ... 1673
Mean No. between 1776 and 1780	2,706,757	1082	1676 ... 1690
1781 ... 1785	2,823,826	1014	1681 ... 1695
1786 ... 1790	2,884,834	1072	1686 ... 1700
1791 ... 1795	2,974,447	907	1691 ... 1705
In 1800	3,182,132	637	1700 ... 1710
In 1805	3,320,647	837	1705 ... 1715

(J. M.)

APPENDIX.

The following Tables will be found to contain, in a condensed form, the most important vital statistics of England published on this subject since the above article was written :—

Annual Rate per Cent. of Marriages, Births, and Deaths in England, during the Years 1847–57.

	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean. 1847–56.	1857.
Estim. Pop. of Eng. *in thousands* in middle of each year.	17,132	17,340	17,552	17,766	17,983	18,206	18,403	18,619	18,787	19,045	—	19,304
Marriages	·793	·797	·808	·860	·858	·872	·894	·858	·810	·836	·839	—
Births	3·152	3·247	3·294	3·340	3·425	3·428	3·328	3·407	3·380	3·454	3·346	—
Deaths	2·471	2·306	2·512	2·077	2·199	2·236	2·288	2·352	2·266	2·055	2·276	—

Annual Rate of Mortality per Cent. of Males and Females at different Ages in England.

DEATHS TO 100 MALES LIVING.

Years—	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	Average 1838–50.
All ages—	2·343	2·281	2·377	2·242	2·244	2·206	2·245	2·173	2·398	2·549	2·394	2·584	2·147	2·322
0	7·041	7·167	7·542	6·843	7·048	6·898	6·984	6·665	7·760	7·588	7·401	7·513	6·695	7·165
5	·901	·904	1·083	·956	·901	·844	·897	·823	·825	·970	1·043	1·124	·814	·930
10	·519	·512	·542	·510	·501	·478	·473	·466	·507	·550	·530	·646	·467	·515
15	·851	·819	·832	·811	·783	·772	·763	·781	·859	·929	·858	·951	·717	·825
25	1·064	·986	·995	·978	·928	·924	·940	·926	1·025	1·100	1·026	1·243	·879	1·001
35	1·342	1·255	1·266	1·217	1·197	1·218	1·225	1·202	1·272	1·436	1·303	1·581	1·165	1·283
45	1·949	1·798	1·796	1·785	1·733	1·722	1·750	1·715	1·800	2·065	1·864	2·262	1·716	1·843
55	3·410	3·192	3·142	3·137	3·041	3·008	3·051	2·975	3·129	3 649	3·266	3·655	2·980	3·203
65	6·916	6·421	6·678	6·482	6·595	6·578	6·736	6·491	6·758	7·696	6·793	7·244	6·306	6·746
75	14·752	13·874	14·488	14·266	14·578	14·090	14·651	14·400	15·070	17·326	14·986	15·187	14·019	14·745
85	29·745	27·923	30·242	29·650	29·438	28·758	31·716	30 191	32·214	35·553	30·622	29·976	28·555	30·353
95 & up.	49·699	43·112	48·498	46·633	46·427	45·681	43·228	49·035	51·651	56·607	42·435	42·859	38·560	46·494

DEATHS TO 100 FEMALES LIVING.

All ages—	2·136	2·094	2·205	2·085	2·100	2·048	2·085	2·013	2·222	2·381	2·225	2·447	2·014	2·158
0	6·047	6·138	6·432	5·861	6·023	5·897	5·885	5·657	6·675	6·553	6·396	6·488	5·738	6·138
5	·895	·935	1·113	·963	·925	·848	·902	·800	·813	·951	·997	1·102	·810	·927
10	·543	·535	·569	·520	·512	·485	·503	·476	·533	·577	·566	·653	·491	·536
15	·854	·848	·868	·842	·830	·784	·810	·815	·870	·919	·878	1·000	·777	·853
25	1·046	1·007	1·033	1·007	1·005	·976	1·006	·980	1·048	1·173	1·090	1·347	·988	1·054
35	1·313	1·248	1·269	1 227	1·220	1·227	1·200	1·188	1·242	1·422	1·301	1·617	1·169	1·280
45	1·660	1·549	1·567	1·542	1·526	1·484	1·525	1·467	1·559	1·789	1·589	1·998	1·473	1·594
55	2·977	2·730	2·829	2·740	2·744	2·692	2·773	2·668	2·783	3·226	2·860	3·355	2·625	2·846
65	5·919	5·554	5·899	5·841	6·013	5·877	6·052	5·856	6·156	6·964	6·072	6·596	5·717	6·040
75	13·281	12·519	13·541	13·375	13·084	13·037	13·494	13·036	13·794	15·945	13·604	14·028	12·684	13·494
85	26·463	25·242	28·394	28·255	28·438	27·655	28·434	27·569	30·350	32·104	27·623	28·028	25·922	28·037
95 & up.	41·099	39·915	46·199	45·907	42·832	46·679	44·616	42·036	52·200	53 230	46·816	43·323	42·927	45·214

The Table may be read thus :—Of 100 Males living of the age of 35 and under 45, 1·342 died in 1838, 1·255 in 1839, 1·217 in 1841, and so on for other years ; a correction for increase of Pop. having been made for each Age at each Year. (The data upon which these Tables are constructed appeared in the Census Report for 1851 ; and in the Ann. Reps. of the Reg. Gen., particularly the 6th.)

Mortality, Law of.

Countries *arranged according to Mortality in Native Race, with Ratio of Deaths in every* 1000 *of Population per Annum.*

Mortality, Law of.

Montserrat	6·7	Mechlenburg-Schwerin	21·1	Gozo	26·3	Venice, Province	32·2
Tortola	9·6	Teneriffe	21·1	Sierra Leone	26·3	Galicia	32·7
New Zealand	11·4	French Possess. in India	21·2	Gomera	26·4	Lombardy	32·8
South Australia	12·7	Canary Islands	21·4	Corfu	26·4	Franconia	33·0
Western Australia	13·2	England and Wales	21·4	Nevis	26·9	Zante	33·1
Newfoundland	13·2	St Helena	21·7	Tyrol	27·1	Algiers	33·3
Van Diemen's Land	13·3	Scotland	22·2	Saxony	27·2	Moldavia	34·0
Ceylon	13·6	Hanover	23·0	White Russia	27·2	Wurtemberg	34·6
Ithaca	13·8	St Pierre and Miguelon	23·2	Holland	27·6	New Russia	35·4
Norfolk Island	14·5	Dalmatia	23·2	Malta	28·1	Grenada	35·5
Java	14·6	Sweden	23·3	Upper Austria	28·2	Lower Austria	36·5
Ireland	14·8	Ionian Islands	23·5	Styria	28·2	Trinidad	37·1
New South Wales	15·2	France	23·6	Prussia	28·3	Great Russia	38·1
Cerigo	15·5	Hierro	23·6	N. Russian Provinces	28·9	Iceland	39·1
Bahama Islands	15·9	Lower Canada	23·9	Bohemia	29·1	Military Frontier	40·0
Palma	17·3	Isle of Bourbon	24·1	Sardinia	29·1	Ural Provinces	40·1
Venezuela	18·3	Barbadoes	24·2	Moravia and Silesia	29·2	Sicily	40·3
Bermudas	18·5	Malacca	24·3	Naples	29·2	Little Russia	41·3
Cape of Good Hope	18·7	Santa Maura	24·4	Bavaria	29·2	Volta and Caspian Prov.	41·8
New Granada	19·2	U. Canada (Indians)	24·5	Baltic Provinces	29·3	Tobago	42·3
Cephalonia	19·3	Switzerland	24·5	Tuscany	29·5	Mauritius	45·3
Lanzarote	19·3	Lucca	24·6	Martinique	29·6	Dominica	46·2
Norway	19·5	St Christopher	24·6	Siberia	30·0	Senegal	47·2
Portugal	20·0	Canary	25·1	Illyrian Coast	30·1	Honduras	57·8
Fuerteventura	20·1	Belgium	25·2	Nova Scotia	30·3	Gambia	68·2
Transylvania	20·5	Hungary	25·5	Guadaloupe	30·5	Azores, Oriental	28·9
Madeira	20·6	Carinthia and Carniola	26·1	Demerara	30·8	Central	20·5
Denmark	21·1	Paxo	26·2	Lithuania	31·3	Occidental	102·8

Cities *arranged according to Mortality in Native Race, with Ratio of Deaths in every* 1000 *of Population per Annum.*

St John's, Newfoundland	13·7	Glasgow	28·7	Cape Town	31·3	Amsterdam	39·0
Lowell, United States	14·4	Edinburgh	24·0	Innsbruch	31·7	Barcelona	39·7
Hobart Town, Van D. Ld.	15·2	Dundee	25·5	Odessa and Russ. townsh.	31·7	Stuttgart	40·0
Berbice, Demerara	19·5	Aberdeen	21·3	Manchester	32·1	Prague	40·0
Cork	19·7	Philadelphia	26·8	Hamburg	32·2	Stockholm	42·2
Boston	20·3	Copenhagen	26·9	Liverpool	33·6	Trieste	45·3
Frankfort	20·4	Leipsic	26·9	Konigsberg	34·2	Vienna	46·1
Geneva	22·2	Turin	27·2	Laibach	34·4	Rennes	45·8
Gibraltar	22·3	Havannah	27·5	Brussels	36·3	Rome	47·4
London	23·1	Archangel	28·4	Brunn	36·5	Venice	47·9
St Petersburg	24·7	Leghorn	28·5	Milan	36·7	Vicenza	51·3
Hanover	24·5	Berlin	29·4	Genoa	36·9	Calcutta	51·1
Cologne	25·0	Stettin	29·4	Cadiz	37·0	Zara	52·0
Belfast	25·4	Paris	29·8	Queretaro, New Spain	37·9	Valparaiso	53·1
Birmingham	26·0	Dublin	30·5	Guanaxuato, do.	38·8	New Orleans	60·6
New York	26·3	Dresden	30·7	Linz	38·1	Limburg	65·8
Baltimore	26·6	Gratz	30·8	Naples	38·8	Alexandria	73·0
Scottish Towns	26·6	Dantzic	31·3	Breslau	38·8	Groningen	94·0

Mortality of White Races of Mankind in Foreign Countries.

TROOPS, &c.		China (Chusan)	37·0	Bombay (Queen's troops)	105·2	Cumberland District, Australia (Rom. Catholics)	22·5
New Zealand	11·4	Madras (E. I. Co's. troops)	38·4	Honduras	103·0	New South Wales (with convicts)	23·2
Cape of Good Hope	13·7	Antigua and Montserrat	40·6	Trinidad	106·3	Do. (excluding convicts)	33·0
New South Wales	14·0	Newfoundland	41·0	Senegal	121·0	Cumberland District, Australia (Protestants)	26·1
Van Diemen's Land	14·0	United States (Middle)	44·6	Jamaica	121·3	Adelaide alone	27·9
Norfolk Island	14·5	Madras (Queen's troops)	48·0	Spain (British troops)	118·6	Antigua and Montserrat	29·0
Nova Scotia, New Brunswick	14·7	United States (South)	48·5	St Lucia	122·8	Malacca (Europeans)	30·0
United States (North)	15·6	Bombay (E. I. Co's. troops)	50·7	Dominica	137·4	Cape Town	31·3
Canada	16·1	St Vincent's	54·9	Tobago	152·8	Calcutta	35·1
Malta	16·3	West Indies	55·1	Bahamas	200·0	Malacca (Portuguese descendants)	38·4
Bengal Civil Servants	21·1	Grenada	61·8	China	285·0	Barbadoes	39·5
Gibraltar	21·4	East Indies	68·9	Burmah	426·0	Algiers	40·5
Newfoundland	22·0	Ceylon	69·8	Sierra Leone	483·0	Mauritius (white and coloured pop.)	45·3
Ionian Islands	25·0	St Kitts, Nevis, Tortola	71·0	Cape Coast	668·0	Honduras	57·8
Bourbon, Isle of	25·6	Bengal (E. I. Co's. troops)	73·8	St Domingo	943·1	New Orleans	73·7
Mauritius	27·4	British Guiana	84·0			St Lucia	82·1
French Guiana	28·1	Morea, Greece	84·6	RESIDENTS.		Calcutta (Portuguese and French descendants)	124·4
Bermudas	28·8	Algiers	87·8	Tobago	10·5		
St Helena	33·0	Bengal (Queen's troops)	90·2	Cape of Good Hope	13·8		
Norfolk Island (new convicts)	33·0	Guadaloupe	96·3	Van Diemen's Land (excluding convicts)	20·1		
Tenasserim	34·6	China (Hong Kong)	97·5	St Helena	21·7		
		Martinique	100·4	Malta (British only)	22·5		
		Zealand	103·0				

Mortar ‖ Mortimer.

MORTAR, a chemical utensil, used for the division of bodies, partly by percussion and partly by grinding. Mortars have usually the form of an inverted bell, and are made either of iron, stone, stoneware, or glass, &c., according to the use to which they are applied. For the finer chemical processes they are often composed of agate, flint, or porphyry. The matter intended to be pounded is put into them, and then struck and bruised by an instrument denominated a *pestle*.

MORTAR, in the military art, is a short cannon of a large bore, with chambers. It is made of brass or iron, and is used to project hollow shells, filled with powder, called bombs, and sometimes also carcasses. (See ARTILLERY.) The mortars used at sea are fixed in bomb-vessels, which are constructed for their reception; they are made somewhat longer and much heavier than those employed on land. The mortar is the most ancient kind of cannon, and was first made in England in 1543. (See GUNNERY.)

MORTARA, a walled town of the kingdom of Sardinia, in Italy, the capital of the province of Lomellina, is situated on an eminence on the right bank of the Arbogna, which is here crossed by a bridge, 14 miles S.S.E. of Novara. The principal buildings are,—three churches, a courthouse, a theatre, several schools, and an hospital. There is some trade in rice, grain, and silk. The situation of the town is unhealthy; and from this circumstance it is said to derive its name, being a corruption of *mortis ara*. Another account, however, derives this name from the battle fought here in 774 A.D., when the Lombards were defeated by Charlemagne with great slaughter. Pop. 5316.

MORTIER, EDOUARD-ADOLPHE-CASIMIR-JOSEPH, Duke of Treviso and Marshal of France, was born at Chateau-Cambresis in 1768. At the age of twenty-three he entered the army of the Revolution as captain in a battalion of volunteers. He fought with distinction at the battles of Jemeppes and Neerwinden, and was gradually promoted. In 1799 the rank of general of brigade had been conferred upon him. Serving soon afterwards as a general of division in the army of Switzerland, he led the right wing of Massena's forces in the battle of Zurich. His next important service was the occupation of the electorate of Hanover in 1803. On his return in the following year, his valour was publicly acknowledged by Bonaparte; and a marshal's baton and the rank of general of the consular guard were conferred upon him. He supported his reputation at the battle of Friedland in 1807. The title of Duke of Treviso was bestowed upon him in 1808. At the head of the 5th corps in the army of Spain he defeated the Spaniards at Ocana in 1809, and at Jebora in 1811. He served under Napoleon in the Russian expedition, and at all the important battles of 1813 and 1814. In this latter year the defence of Paris against the victorious allies was entrusted to him and Marshal Marmont. He was one of those who sent in their allegiance to Louis XVIII. at the commencement of the Hundred Days, recalled it when Napoleon landed from Elba, and renewed it after the battle of Waterloo. Yet his attachment to the Bourbons did not prevent him, after the Revolution of 1830, from rising into favour with Louis Philippe. He was riding by the side of that monarch at a review of the National Guard of Paris, on the 28th July 1835, when the infernal machine of Fieschi, intended for the destruction of royalty, exploded. Marshal Mortier was among the number of those who were struck dead on the spot.

MORTIMER, JOHN HAMILTON, a noted artist, was the son of a collector of customs, and was born at Eastbourne in Sussex in 1741. His early-developed talent for painting found congenial subjects among the rocks and woods of his native shore. He repaired to London about his eighteenth year, and studied his art first under Hudson, and afterwards under Pine. At the same time he executed several imitations of the antique figures in the gallery of the Duke of Richmond. Some of these secured for him premiums from the Society for the Encouragement of Art, and facilitated his admission into the private academy in St Martin's Lane. But his first introduction to general notice was his representation of "Edward the Confessor seizing the Treasures of his Mother," a painting which, by the judgment of Sir Joshua Reynolds, received the prize of fifty guineas, in preference to a rival picture by Romney. His great work, "St Paul preaching to the Britons," was executed soon afterwards, and raised him to the height of popularity. Yet owing to his rapidity of execution, and his tameness in colouring, Mortimer did not reach a high excellence in historical painting. He excelled far more in the designs which he threw off for the booksellers. In these his facile hand sketched with unerring skill the forms that his happy fancy conceived or his well-stored memory suggested. He was also unrivalled in his feats of rapid and dexterous drawing; and in his creation of fantastic and striking images. This eccentricity and fondness for display was not confined merely to his art,—it extended also to his ordinary life. Gaudy dress, convivial pleasures, athletic contests, and grotesque buffoonery, occupied a great part of his time and attention. At length he married and settled down into sobriety of life, but not before his constitution had become prematurely weak. In 1775 his health began to decline, and rendered it necessary that he should retire into the pure air of the country. His rapid power of painting, however, remained unimpaired; and in his rural retreat at Aylesbury in Berks he produced in one year a number of pictures of the united value of L.900. He returned to London in 1778, and died of a fever in February of the following year. The best known historical paintings of Mortimer, in addition to the two already mentioned, are "King John signing the Magna Charta," "The Battle of Agincourt," "The Origin of Health," "The Tragic and Comic Muses," "Sextus consulting Erietho from Lucan," "The Incantation," and "Vortigern and Rowena." (See Cunningham's *Lives of British Painters*, &c.)

Mortmain.

MORTMAIN, or ALIENATION IN MORTMAIN (*in mortua manu*), is an alienation of lands or tenements to any corporation, sole or aggregate, ecclesiastical or temporal. But these purchases having been chiefly made by religious houses, in consequence of which the lands became perpetually inherent in one dead hand, this occasioned the general appellation of *mortmain* to be applied to such alienations, and the religious houses themselves were principally considered in framing the statutes of mortmain. In deducing the history of these statutes, it will be matter of curiosity to observe the great address and subtle contrivance of the ecclesiastics, in eluding from time to time the laws in being, and the zeal with which successive Parliaments pursued them through all their finesses; how new remedies were still the parents of fresh evasions, until the legislature at last, though with difficulty, obtained a decisive victory.

By the common law, any man might dispose of his lands to any other private man at his own discretion, especially when the feudal restraints of alienation were worn away. Yet in consequence of these it was always, and still is, necessary for corporations to have a license of mortmain from the crown, to enable them to purchase lands; for as the sovereign is the ultimate lord of every fee, he ought not, unless by his own consent, to lose his privilege of escheats and other feudal profits, by the vesting of lands in tenants who can never be attainted or die. Such licenses of mortmain appear to have been necessary amongst the Saxons above sixty years before the Norman conquest. But, besides this general license from the King as lord paramount of the kingdom, it was also requisite, whenever there was a mesne or intermediate lord between the King and the alienator, to obtain his license also for the alienation of the

Mortmain. specific land; and if no such license was obtained, the King or other lord might respectively enter on the land so alienated in mortmain, as a forfeiture. The necessity of this license from the crown was acknowledged by the Constitutions of Clarendon, in respect of advowsons, which the monks always greatly coveted, as forming the groundwork of subsequent appropriations. Yet such were the influence and ingenuity of the clergy, that notwithstanding this fundamental principle, we find that the largest and most considerable donations of religious houses happened within less than two centuries after the Conquest. When a license could not be obtained, they contrived that, as the forfeiture for such alienations accrued in the first place to the immediate lord of the fee, the tenant who meant to alienate should first convey his lands to the religious house, and instantly take them back again to hold as tenant to the monastery, which kind of instantaneous seisin was probably given not to occasion any forfeiture; and then, by pretext of some other forfeiture, surrender, or escheat, the society entered into those lands in right of such their newly-acquired signiory, as immediate lords of the fee. But when these donations began to grow numerous, it was observed that the feudal services ordained for the defence of the kingdom were every day visibly withdrawn; that the circulation of landed property from man to man began to stagnate; and that the lords were curtailed of the fruits of their signiories, their escheats, wardships, reliefs, and the like. To prevent this, therefore, it was ordained by the second of King Henry III.'s great charters, and afterwards by that printed in the common statute-books, that all such attempts should be void, and the land forfeited to the lord of the fee.

But as this prohibition extended only to religious houses, bishops and other sole corporations were not included therein; and the aggregate ecclesiastical bodies, who had among their counsel the most learned men that they could get, found many means to creep out of this statute; by buying in lands which were *bonâ fide* holden of themselves as lords of the fee, and thereby evading the forfeiture; or by taking long leases for years, which first introduced those extensive terms, for a thousand or more years, which are now so frequent in conveyances. This produced the statute *De Religiosis*, 7 Edward I., which provided, that no person, religious or other whatsoever, should buy or sell, or receive under pretence of a gift, or term of years, or any other title whatsoever, nor should by any art or ingenuity appropriate to himself any lands or tenements in mortmain, upon pain of the immediate lord of the fee, or in default of him for one year the lords paramount, and in default of all of them the King, entering thereon as a forfeiture.

This seemed to be a sufficient security against all alienations in mortmain. But as these statutes extended only to gifts and conveyances between the parties, the religious houses now began to set up a fictitious title to the land which it was intended they should have, and to bring an action to recover it against the tenant, who, by arrangement and collusion, made no defence; and thereby judgment was given for the religious house, which then recovered the land by a sentence of law upon a supposed prior title. And thus they had the honour of inventing those fictitious adjudications of right which afterwards became the great assurance of the kingdom, under the name of *common recoveries*. But upon this it was enacted by the second statute of Westminster, 13 Edward I., c. 32, that in such cases a jury shall try the true right of the demandants or plaintiffs to the land; and if the religious house or corporation be found to have it, they shall still recover seisin; otherwise it shall be forfeited to the immediate lord of the fee, or else to the next lord, and finally to the King, upon default of the immediate or other lord. A similar provision was made by the succeeding chapter, in case the tenants should set up crosses upon their lands, the badges of knights templars and hospitallers, in order to protect them from the feudal demands of their lords, by virtue of the privileges of those religious and military orders. And so careful was this prince to prevent any future evasions, that when the statute of *Quia emptores*, 18 Edward I., abolished sub-infeudations, and gave liberty to all men to alienate their lands to be holden of their next immediate lord, a proviso was inserted that this should not extend to authorize any kind of alienation in mortmain. When, afterwards, the method of obtaining the King's license by writ of *ad quod damnum* was marked out by the statute 27 Edward I., st. 2, it was further provided, by statute 34 Edward I., st. 3, that no such license should be effectual without the consent of the mesne or intermediate lords. Mortmain.

Yet still it was found difficult to set bounds to ecclesiastical ingenuity; for when the clergy were driven out of all their former holds, they devised a new method of conveyance, by which the lands were granted, not to themselves directly, but only to nominal feoffees for the use of the religious houses, thus distinguishing between the possession and the use, and receiving the actual profits, whilst the seisin of the land remained in the nominal feoffee, who was held by the courts of equity, then under the direction of the clergy, to be bound in conscience to account to his *cestuy que use* for the rents and emoluments of the estate. And it is to these inventions that our practitioners are indebted for the introduction of uses and trusts, the foundation of modern conveyancing. But unfortunately for the inventors themselves, they did not long enjoy the advantage of their new device; for the statute 15 Richard II., c. 5, enacts, that the lands which had been so purchased to uses should be admortised by license from the crown, or else be sold to private persons; and that for the future, uses should be subject to the statutes of mortmain, and forfeitable like the lands themselves. And as the statutes had been notoriously eluded by purchasing large tracts of land adjoining to churches, and consecrating them by the name of "churchyards," such subtle imagination was also declared to be within the compass of the statutes of mortmain. Civil or lay corporations, as well as ecclesiastical, were also declared to be within the mischief, and of course within the remedy provided by those salutary laws. Lastly, as during the times of Popery lands were frequently given for superstitious uses, though not to any corporate bodies, or were rendered liable in the hands of heirs and devisees to the charge of obits, chantries, and the like, which were equally pernicious with actual alienations in mortmain; therefore, at the dawn of the Reformation the statute 23 Henry VIII., c. 10, declared that all future grants of lands for any of the purposes aforesaid, if granted for any longer term than twenty years, should be void.

But during the whole of this time it was in the power of the crown, by granting a license of mortmain, to remit the forfeiture, as far as related to its own rights, and to enable any spiritual or other corporation to purchase and hold any lands or tenements in perpetuity—a prerogative which is declared and confirmed by the statute 18 Edward III., st. 3, c. 3. But as doubts were entertained at the time of the revolution how far such license was valid, since the King had no power to dispense with the statutes of mortmain by a clause of *non obstante*, which was the usual course, though it seems to have been unnecessary; and as by the gradual declension of mesne signiories through the long operation of the statute of *Quia emptores*, the rights of intermediate lords were reduced to a very small compass; it was therefore provided by the statute 7 and 8 William III., c. 37, that the crown for the future, at its own discretion, might grant licenses to alienate or take in mortmain, of whomsoever the tenements might be holden.

After the dissolution of monasteries under Henry VIII., though the policy of the next successor affected to grant

Morton. a security to the possessors of abbey lands, yet, in order to regain as much of them as either the zeal or timidity of their owners might induce them to part with, the statutes of mortmain were suspended for twenty years; and during that time any lands or tenements were allowed to be granted to any spiritual corporation without any license whatsoever. And long afterwards it was enacted by the statute 17 Car. II., c. 3, that appropriators might annex the great tithes to the vicarages, and that all benefices under L.100 per annum might be augmented by the purchase of lands without license of mortmain in either case; and the like provision has been since made in favour of the governors of Queen Anne's Bounty. It has also been held, that the statute 13 Henry VIII. before mentioned did not extend to anything but superstitious uses, and that therefore a man may give lands for the maintenance of a school, an hospital, or any other charitable uses. But as it was apprehended from recent experience that persons on their deathbeds might make large and improvident dispositions even for these good purposes, and defeat the political ends of the statutes of mortmain, it was therefore enacted by the statute 9 Geo. II., c. 36, that no lands or tenements, or money to be laid out thereon, should be given for or charged with any charitable uses whatsoever, unless by deed indented, executed in the presence of two witnesses twelve calendar months before the death of the donor, and enrolled in the Court of Chancery within six months after its execution (except stocks in the public funds, which may be transferred within six months previous to the donor's death), and unless such gift were made to take effect immediately, and were without power of revocation; and that all other gifts should be void. The two universities, their colleges, and scholars upon the foundation of the colleges of Eton, Winchester, and Westminster, were excepted from the operation of this act; but such exemption was granted with this proviso, that no college should be at liberty to purchase more advowsons than were equal in number to one moiety of the fellows or students upon the respective foundations.

Such is the history and condition of the law of mortmain, as stated by Blackstone (*Com.*, b. ii., c. 20). It has been to a certain extent modified by recent statutes. The Church-Buildings Acts, consolidated in 1840 (3 and 4 Vict., c. 60), exempted from the license in mortmain endowments for the sites of churches, parsonages, or glebes, "or for the use or benefit of any church or chapel, or of the incumbent or minister thereof, or for repairs thereof." There have been further partial changes in the Church-Buildings Acts, the latest in 1851 (14 and 15 Vict., c. 97), and property dedicated to purposes of education. A reference will be found to several of the statutes containing these modifications in the act 15 and 16 Vict., c. 49.

MORTON, Cardinal John, was born at Bere in Dorsetshire in 1410. He was educated at Baliol College, Oxford, and became principal of Peckwater Inn, now merged in Christ Church. His learning and talents introduced him to Cardinal Bourchier, and thus set him on the path to preferment. He was recommended to the notice of Henry VI., and was appointed a member of the Privy Council. Not less successful in the reign of Edward IV., he was nominated Bishop of Ely and Lord Chancellor of England in 1478, and was finally appointed one of the King's executors. His tried probity, however, did not fit him for the lawless service of the next King, Richard III., and he was imprisoned in the Castle of Brecknock. But contriving to escape, he fled to the Earl of Richmond on the Continent, and is said to have been the first who proposed a marriage between that prince and Elizabeth, the eldest daughter of Edward IV. At the death of Richard III., and the accession of Henry VII., a succession of preferments awaited Morton. He was appointed a privy-councillor; he was raised to the see of Canterbury in 1486; the chancellorship was again conferred upon him in 1487; and Pope Alexander VI. created him a cardinal in 1493. His death took place in September 1500. Morton ‖ Moscow.

Morton, *Thomas*, a successful writer of comedy, was born at Durham in 1764. After attending school at London, he enrolled as a student of Lincoln's Inn; but his love for dramatic amusements led him to spend his evenings in the theatres, and to study the drama more than the law. The knowledge of stage effect which he thus acquired was employed in the production of numerous plays. By their skilfully-arranged scenes, their strongly-contrasted characters, and their sudden transitions of feeling, these dramas secured the attention of mixed audiences. The acting of Lewis, Munden, and Emery greatly increased their effect. Accordingly, several of them, such as *The Way to get Married*, *A Cure for the Heart-Ache*, *Speed the Plough*, *The School of Reform*, and *The Invincibles*, secured a footing on the stage, which they still retain. Morton died in 1838.

MOSAIC, or Mosaic Work, an assemblage of little pieces of glass, marble, precious stones, and other substances, of various colours, cut in prisms, and fixed in a ground of cement, in such a manner as to imitate the colours and gradations of painting. This sort of work was used both for pavements and for ornamenting walls until a comparatively late period in the middle ages. It was much practised by the Byzantine artists, who re-introduced it into Italy. The most famous kinds of mosaic of recent times are the Roman and the Florentine. Pictures in mosaic were wrought at Rome in the eleventh and twelfth centuries. Some of the finest specimens of mosaics in existence are to be found in St Peter's at Rome. The origin of the name *mosaic* has not been accurately determined. The most probable derivation, however, is from the Greek μυσειον, Lat. *opus musivum*. (See the *Glossarium* of Ducange.)

MOSCHUS, a Greek bucolic poet, flourished at Syracuse about the close of the third century B.C. His genius was fostered by a study of the works, and probably by the friendship, of the pastoral poet Bion. He was also, according to Suidas, acquainted with the grammarian Aristarchus. Theocritus was his great model; but instead of the exquisite simplicity of that celebrated poet, he often displayed an excess of ornament and an over-refinement of style. His four extant idyls are *Fugitive Love*, *Europa*, *An Elegy on Bion*, and *Megara*. They have been usually edited with the works of Bion. (See Bion.) Many modern writers of different nations have imitated and translated them.

MOSCOW, the ancient capital of Russia, is situated in the government of the same name, in 55. 45. 13. N. Lat., and 55. 17. 11. E. Long., 698 versts, or 466 English miles, from St Petersburg, and 1349 versts, or 902 English miles, from the frontiers of Poland. The soil in its immediate neighbourhood is sandy and argillaceous. A great part of it is under cultivation, and is highly productive. The situation of Moscow is most happily chosen.

The town is divided into two unequal parts by the River Moskva. On the left bank, on which the larger part of the city stands, the surface is broken and hilly. On the right, at the distance of about a mile, rises an amphitheatre of low hills, covered with wood, called the Sparrow Hills, from the summit of which you obtain a fine view of the city. At your feet the river winds through beautiful meadows; rising beyond, you see a mingled mass of towers, gilded and painted domes, churches, monasteries, and palaces. The whole, when seen on a sunny day and under a clear sky, possesses an almost unearthly splendour, from the dazzling whiteness of the buildings, and the glancing brilliance of the gilded domes of the churches.

The River Moskva rises in the S.E. of the government of Moscow, towards the district of Mojaisk. Its course is very winding, and hence its name, which signifies "the winding" or "serpentine." In spring it becomes navigable

Moscow. by the melting of the snow and ice, and then by means of the River Oka, its junction with which falls into the Volga, affords a communication between Moscow and that great river.

The length of Moscow from the Sparrow Hills on the S.W. to the Preobrajensky Barrier on the N.E., is about 14 versts, or 10 English miles. Its width from E. to W. is about 10 versts, or 7 English miles; its circumference is about 20 English miles. It covers a larger extent of ground than any other European capital, excepting London and Constantinople.

Moscow is divided into three distinct circles within the rampart or earthen walls thrown round the whole city. The first or most remote from the centre is called the *Zemlianoi Gorod*, or Earth City. It lies between a line of streets called the *Sadova*, or Garden Street, because most of the houses have a garden or inclosure in front, and the Boulevards. The second division, the *Beloi Gorod*, or White City, is that part of the town which lies between the Boulevards and the Kitai Gorod. The general form of the Boulevards is that of an avenue of lime-trees for foot-passengers, on either side of which runs a carriage-road or street, the intervening space being filled up with clumps of small trees, shrubs, and flowers. The Beloi Gorod is the most aristocratic division of the town. The last circle is inclosed by an embattled wall, and covers a very extensive space of ground. It is almost entirely occupied by what is termed the Gosteeny-dvore, an immense mass of buildings divided into rows of shops, warehouses, and store-houses, each row being devoted to the sale of a particular kind of goods, and having the name of the article sold,—as, *e.g.*, Knife Row, Linen Row, Silk Row, Plate Row, &c. This division is called the *Kitai Gorod*, or Chinese Town. The origin of the name is not exactly known. One hypothesis is, that it was called after a small town of Lithuania of the same name, which was the birthplace of Helen, mother of Ivan IV., who built this division of the town. The most probable account of the name is, that it was at one time the great mart for Chinese goods. When, however, it is spoken of separately from the other divisions, it is simply called "Gorod," just as in London we speak of the "City." It may be added, that in other respects it bears a striking analogy to the "City" of London, being the centre of trade and business, and having within its limits the great commercial and civic buildings.

On the S.W. of the Kitai Gorod, and separated from it by a large square called the *Crassnaia*, or Red Square, stands the Kremlin, the ancient fortress of the city. It is built on the brow of a hill, at the foot of which flows the Moskva River. Its form is irregular, but almost approaching a triangle. A high crenellated wall surrounds it, broken at intervals by towers of various heights, and of pyramidal or spiral form. On three sides runs a sort of boulevard; and on the fourth side, over the bed of a small stream called the Neglinna, which is now conveyed by an underground canal into the Moskva, is a large public walk called the Alexander Gardens, from having been laid out by order of the Emperor Alexander I. These gardens are the work of a Scotchman. Taken as a whole, the Kremlin is one of the most original, beautiful, and striking objects that can well be conceived. Its commanding situation on the banks of the Moskva River; its high and venerable white walls, with its variously-coloured towers and steeples; the number and size of some of its fine buildings, with their painted roofs; the cathedrals, churches, monasteries, and belfries, their domes gilt, tin-plated, or green;—the whole presents a grandeur and beauty indescribable and altogether unique.

The interior of the Kremlin contains the imperial palace, a modern erection, replacing the older one, which in former days had been occupied by the Tsars, and in which Napoleon had spent a part of his disastrous sojourn in Moscow. Though a fine and spacious building, it strikes the eye as out of character with the general style of the Kremlin. Behind the new palace is a small one of great antiquity. The rooms have vaulted ceilings, completely covered with arabesque paintings, exceedingly rich and curious. Moscow.

The cathedrals are three in number,—the Church of the Assumption, built in 1472 A.D., where the Emperors of Russia are always crowned; the Church of the Archangel Michael, where, until St Petersburg was built, the Tzars were buried; and the Church of the Annunciation. Near these churches stands the Ivan Veliki tower, or Tower of John the Great. It was built by Boris Goudanoff about the year 1600. The best view of Moscow is to be obtained from it, as it commands more objects than that from any other place.

At the foot of the Kremlin stands the great bell of Moscow, said to be the largest in the world. Its circumference at the bottom is nearly 68 feet, and its height more than 21 feet. In the stoutest part it is 23 inches thick, and its weight has been computed to be 443,772 lb. It has never been hung, and was probably cast on the spot in which it now stands. When Dr Clarke visited Moscow in the year 1800 it was in a pit, the mouth of which was covered, and the entrance was by a trap-door, beneath which were ladders. Since then it has been raised, and now stands on a stone pedestal. A piece of the bell has been broken off. The fracture was occasioned, according to Dr Clarke, by water having been thrown upon it when heated by the building erected over it being on fire.

The other buildings of importance in the Kremlin are,—the Granite Palace or treasury, where the crowns, sceptres, coronation robes, &c. &c., are kept; the Senate-House; the Tchoudoff monastery; the Arsenal, along the outside of which lie a great number of cannon, most of them foreign, and taken in the campaign of 1812-14. Amongst them are two Russian cannon of immense size; the mouth of the largest is about 2 feet 6 inches in diameter; the weight of the metal is 2200 poods; the ball weighs 80 poods, or about 1 ton.

The Kremlin is approached by five gateways. One facing N.W., and opening into the Great Square, which divides the Kremlin from the Kitai Gorod, is called the *Spaskoi Varott*, or Gate of the Saviour, and sometimes the Holy Gate. Through this gate no male person is allowed to go without taking off his hat. Outside this gate stands one of the most remarkable buildings in Moscow,—the church of Vassili Blashenny, or Basilius the Blissful, erected by Ivan the Terrible after the conquest of Kasan—the work of an Italian architect. It is a strange blending of every imaginable style of architecture, thrown together in the most capricious and fanciful manner. In its principal feature, however, it is Tartar, and bears a strong resem blance to the oriental mosque. Its numerous and heavy cupolas, surmounted by gilded crosses, exhibit a striking contrast of colour and ornament.

Another gate of the Kremlin, also facing the N.W., and opening into the Great Square, is called the *Nicholskoi Varott*, or Gate of St Nicholas, and was the one blown up by the French. It has been restored with considerable taste and elegance.

About the middle of the Great Square is a monument consisting of the statues of Minim, citizen of Novogorod, and Prince Pojarsky, who together delivered Moscow from the Poles; an event which was followed by the election of Michael Feodorovitch, the first of the Romanoff dynasty, to the throne.

Among the remarkable buildings of Moscow should be mentioned the Church of our Saviour, not yet quite finished, erected in commemoration of the retreat of the French after the burning of Moscow in 1812. It was begun on the edge of the Sparrow Hills, and near the

Moscow. spot where Napoleon took his first view of Moscow; but the ground giving way, the site was changed to the spot on which it now stands, on the opposite side of the river. The building is in the Byzantine style of architecture, and with its gilded domes is a conspicuous object, seen from every side of the city.

Another remarkable building, standing on high ground, in the Zemlianoi Gorod is the *Sukareva Bashnoi*, or Tower of Sukareff. It is now used as a reservoir to receive the water with which Moscow is supplied. The water, which is of excellent quality, is brought from the far-famed springs of Metischa, forty-two in number. From the Sukareva Bashnoi it is conveyed by underground pipes to fountains in various quarters of the town. The whole was done by order of Katherine II.

The Foundling Hospital, a magnificent pile of building on the banks of the Moskva, was founded by Katherine II. in 1763. Any person may bring an infant, and without giving any further information than whether it has been baptized, may leave it there. If at any future time the parents wish to have the child again, a card is given them with the number in which it is entered in the register of the establishment, the same number being hung round the child's neck. Connected with this hospital is a school for the education of orphan young ladies of noble birth; also a Lombard or loan bank, and a widow alms-house for the widows of civil officers.

Of the educational establishments of Moscow, the university is divided into 4 faculties, and had, in 1857, 40 professors and lecturers, and 1473 students. Of these last 63 belonged to the historico-philological faculty, 296 to the law, 950 to the medical, and 160 to the mathematical. The cadet corps, or military schools, are 3 in number, containing altogether 1285 cadets. The gymnasia, or public schools, are 4 in number. There is 1 commercial academy and 1 commercial school, 1 seminary for the education of the clergy, 1 academy for divinity students who desire a superior education to that given in the seminary. The Katherine Institution, founded by Katherine II., is devoted to the education of young ladies, and contains 290 pupils. The Elizabethan Institution, founded by the Empress Elizabeth, contains 173 pupils. The house of education in connection with the Foundling Hospital, already referred to, contains 700 pupils.

The number of churches is 375; of chapels, *i.e.*, places of worship connected with public institutions, 26; of monasteries, 21.

Moscow is a great centre of internal commerce, its position being peculiarly favourable for this. Its principal foreign trade is with China, with which for the teas of that country it used to exchange manufactured goods. Owing, however, to the frauds practised by the Moscow merchants, the Chinese will now only take gold and silver. Moscow is now the seat of the principal manufactures of Russia. There are, according to the latest statistics, in the government of Moscow 484 manufactories. Of these there are 135 of cotton, 117 silk, 30 cloth, 10 of chemical drugs and instruments, 7 of hats, 29 of leather, 1 sugar refinery, 6 distilleries of brandy, 8 of vinegar, 10 tallow foundries, 14 manufactories of tobacco, and some iron foundries, &c., &c.

The climate of Moscow is more healthy than that of most of the capitals of Europe. Its elevated position, the width of its streets, and the low elevation of its houses, allow a free circulation of air; but being unprotected by mountains, the winds are often very violent, and in the early summer vegetation frequently suffers severely from them. The summer is short, and would be very fine but for the sudden changes of weather to which it is subject, so that the winter is generally preferred; the sky is then of wonderful purity, and the respiration easier. The winter generally sets in about the middle of November, and lasts, with occasional thaws of short duration, till the beginning of April; the change from winter to summer is very rapid. Moscow. The mean temperature in winter is 4° below zero, Fahr. Vegetation is vigorous. The ordinary grain crops raised in the neighbourhood of Moscow are rye and wheat. The common vegetables of England thrive well in the gardens in its environs. The silver birch and pine attain the same height as in Great Britain. The commonest trees, in addition to those just mentioned, are the pine, the lilac, and a kind of acacia. The ivy cannot stand the severity of the climate, but is cultivated indoors as an exotic.

History. The origin of Moscow is wrapt in obscurity. The ordinary tradition is that it was founded by Youri Vladimorivitch Dolgorouki, in the middle of the twelfth century; the year given is 1147. The 700th anniversary of its foundation was kept in Moscow in the year 1847. The name of Moscow is supposed to have been taken from the River Moskva, on the banks of which it is built. The history for many centuries is little else than a record of fires, pestilences, sieges, and wars. Probably there is no other city in Europe which has suffered so frequently and so terribly from these calamities as the ancient capital of Russia. Its earliest traditions, alike with that last terrible event with which its name will be for ever associated in the mind of Europe, are of fire and sword. Moskva was for some time only an appendage of the principality of Vladimir, and shared the fate of other towns of that principality, being often sacked and burned by the Tartars. But it gradually grew into notice and importance; and about the middle of the thirteenth century history mentions a prince of Moscow, Michael, surnamed the Brave. The first prince of Moscow who obtained the title of Grand Prince was George Danilovitch, A.D. 1319. From this time the history of Moscow becomes the history of Russia. George was succeeded by his brother Ivan, surnamed Kalita, A.D. 1328. The Tartar khans were then the suzerains of Russia, and the Grand Princes received at their hands their investment to the princedom. Ivan was distinguished for the craft and ability of his dealings with his Tartar masters. He persuaded the primate to remove his residence from Vladimir to Moscow, and thus make the latter city the capital of Russia. The primate's name was Peter; he built the cathedral of the Assumption, and was the first patron saint of Moscow.

The geographical position of Moscow was peculiarly favourable to the grand design entertained by Ivan of consolidation. It formed the central point of those districts which, lying in the neighbourhood of Vladimir, might be expected to form a union of interest with the grand principality; and that union being accomplished by the appointment of a Muscovite prince to the sovereignty, the long-desired concentration of means to free the country from its oppressors was at length obtained. Ivan surrounded Moscow with wooden walls, and rebuilt the Kremlin. He was succeeded by his son Simeon Ivanovitch, surnamed the Proud, A.D. 1339. He carried on his father's policy, but with less success, owing to the dissensions among the Russian princes which disturbed his reign. His grandson Demetrius (A.D. 1359) was a man of great courage and energy, and did much to strengthen and consolidate the Russian power. He surrounded Moscow with stone walls. The most memorable event in the reign of his son and successor Vassili (A.D. 1389), was the retreat of Tamerlane from the walls of Moscow. Russian chroniclers relate that it was owing to the intervention of the Virgin of Vladimir, and that it took place at the moment when the people of Moscow met her image, which at Vassili's order had been sent for from Vladimir. The Grand Prince built a monastery on the spot where the meeting took place, and gave it the name of *Stretenha*, or Place of Meeting. In the course, however, of the same reign Moscow was besieged by another army of Moguls, and Vassili was com-

Moscow. pelled to purchase peace by the sacrifice of his independence. The earlier part of his son Vassili's reign was full of disasters (A.D. 1425), but its termination was happier. He succeeded in freeing Moscow from the Tartar yoke, and consolidated his authority by decisive victories over the Novogorodians. His son Ivan, surnamed the Great (A.D. 1462), extended by conquest the Russian frontier to the Ural Mountains, made himself master of Novogorod, Tver, and Viatka, and formed an alliance with Maximilian, Prince of Austria, against Cassimir, King of Poland, and the Grand Duke of Lithuania. He was the first Grand Prince who took the title of Prince of all the Russias, and the name of Tzar, which is either a corruption of *Cæsar*, or more probably is of eastern origin, and signifies "king." He rebuilt the walls of the Kremlin, and in other respects greatly improved and added to the town. He was succeeded by his son Vassili (1505), who was equally great and prosperous with his father, and by the conquest of Pskoff, Seversky, and Smolensk, he made himself master of the whole of Russia. He was also successful in repelling an attack of the Crimean Tartars. Vassili received the ambassadors of Charles V. and Pope Clement who came to negotiate a treaty between Russia and Lithuania. They were accompanied by Herberstein, who has left an account of his visit to Moscow, written in Latin. The only part of Moscow at this period called the town was the Kremlin. The suburbs were occupied by mechanics. The houses were built at a distance from one another, and surrounded by gardens and corn-fields. The air was remarkably pure and healthy, and there were no endemic diseases. The number of houses was 4500, and the inhabitants 100,000; the shops were filled with the rich merchandise of Europe and Asia. Vassili died suddenly, after a short reign, leaving a son only three years old, A.D. 1543. This was Ivan the Terrible. The name was given him from the horrible crimes and deeds of blood which marked and disgraced the conduct of the latter part of his reign. In the beginning of his reign a terrible fire destroyed almost the whole of Moscow. The most memorable events of his reign were the conquest of Kasan, the taking of Astrachan, and the final destruction of the Tartar power in Russia.

His son and successor Fedor (A.D. 1581) reigned thirty years. The feebleness of his rule gave ample room for the exercise of faction and ambition; and his prime minister, Boris Goudanoff, having caused the death of the young Demetrius, the only direct heir to the throne, was, on the demise of Fedor, elected Tzar A.D. 1598. His son Fedor was dethroned by a monk who pretended to be the Demetrius whom Boris had caused to be put to death, and who obtained the aid of the Poles in support of his pretensions, A.D. 1605. The false Demetrius was driven from the throne and assassinated by Chouisk, who in his turn became Tzar. During his reign there were several pretenders to the throne, one of whom was supported by Sigismund, King of Poland, who took possession of Moscow and held it for two years. It was saved (A.D. 1610) by two Russians—Minim, a simple citizen merchant of Nishni Novogorod, and Prince Pojarsky, a nobleman who had been dangerously wounded by the Poles in a massacre of the Muscovites. They raised an army, and approaching Moscow, the town capitulated, thus relieving the inhabitants at the same time from the horrors of war and famine. Michael Fedorovitch, of the family of Romanoff, and by the female line descended from Ruric, the son of the patriarch of Russia, was then elected Tzar. His son and successor Alexis (A.D. 1645) was distinguished for his wise laws. Feodor, the son of Alexis, was succeeded by Peter the Great A.D. 1681.

The change of residence made by Peter from Moscow to St Petersburg did the former less injury than might have been expected. At first Peter made a law prohibiting, under severe penalties, the building of houses in Moscow; Moscow. but after twenty years the prohibition was withdrawn, and the sovereigns themselves vied with the great families of the empire in embellishing their ancient capital with new monuments of their munificence and power. Peter himself built a large military hospital; and other important buildings have since been erected—among others, a printing-press, a university with two colleges, a foundling hospital, and an arsenal. Katherine II., in particular, magnificently restored the principal cathedrals, and added new buildings; she also prohibited the erection of wooden houses in the Beloi Gorod. At the beginning of this century travellers described Moscow as immense, triangular, half wooden half stone, interspersed with gardens, dirty and badly paved, and in many points more resembling an overgrown village than the second capital of a great empire. The terrible catastrophe of 1812 has, however, made a vast difference in the external appearance of Moscow. On Wednesday, September 15, Napoleon took up his head-quarters in the Kremlin, and on the same day the fire broke out in the shops of the Kitai Gorod. The night of the 16th was illuminated by the fire of a general conflagration. The explosions, the balloons of flame which were seen falling from the tops of towers, showed the means which were being taken to spread the fire. A vast sea of flame illuminated the horizon for miles, and announced to the unhappy Muscovites who still lingered near the town that their homes no longer existed. The different quarters of the town took fire, burned, and disappeared all at once. Heaps of calcined and blackened stones indicated the spots where houses had stood. The silence of terror was only interrupted by a roaring like that of the waves of a stormy sea; this was produced by the wind, which, driving with violence the torrent of flame, hurried on far and wide the destroying element. From time to time whole buildings fell with a crash. Wherever the eye turned nothing could be seen but smoking ruins or devouring flames. Ever and anon was heard the mournful toll of a bell, which sounded like the signal passed between one and another agent in this work of destruction. In spite of the vigilance of the sentinels posted at the houses, the fire spread as if it had been driven by an invisible power. Although a great part of the town was built of wood, it took many days of general conflagration to consume it. At last, in most quarters of the town there were left so few traces of habitations that the streets could hardly be recognised. Human bodies half-burned, and the dead carcases of horses, cows, and dogs, lay in the midst of the ruins. 30,800 houses, besides a great number of palaces, were reduced to ashes; scarcely 6000 buildings were left standing. Among these, however, was the Kremlin, which the fire did not touch. The private loss by the destruction of houses and their contents was calculated at not less than L.30,000,000 sterling, and this was probably under the mark. The question has been often asked, What hand set the torch to this great conflagration? Count Rostopchine, the then governor, to whom fame has commonly attributed it, repudiates the honour in a work entitled *La Verité sur l'Incendie de Moscou*, published in Paris, 1828. The hypothesis that it was the act of the French is most unlikely. Napoleon could never have designed or permitted a calamity of which himself and his army were the first victims. The more probable theory is, that it was the act of the inhabitants themselves, and that Rostopchine set the example of patriotic devotedness. The desolation did not last long; Russian patriotism soon raised from its ashes their holy city, whose destruction had saved their country from foreign oppression. Subscriptions were opened in every part of the empire, and the liberality of the sovereign seconded the enthusiasm of his subjects. Moscow rose like a Phœnix from her ashes, but in greater beauty, and under a newer form. Her original character is not,

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rated by a narrow and well-defined dark line, as shown in figs. 192 and 193. When the aperture in the plate was slightly shifted, the phenomena rapidly changed, assuming successively the forms shown in figs. 194, 195, 196. In the first stage of the change the central dark space became greatly enlarged, and a double sector appeared in the centre. The circle was reduced to about

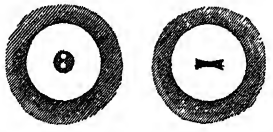

Fig. 192. Fig. 193.

Fig. 194. Fig. 195. Fig. 196.

a quadrant, and was separated by a dark interval from the sector just mentioned. This is shown in fig. 194. The remote sector then disappeared, and the circular arch diminished, as in fig. 195; and as the inclination of the internal ray to the optical axis was farther increased, these two luminous portions merged gradually into two doubly-refracted pencils. This change is shown in fig. 196. In these experiments the emergent rays were received directly by the eye placed close to the aperture on the second surface.

Dr Lloyd succeeded in showing the phenomena on a screen with the sun's light, and he found the light sufficiently distinct when the diameter of the section was 1½ inch. Upon examining the cone with a tourmaline, Dr Lloyd was surprised to observe that one radius only of the circular section vanished in a given position of the tourmaline, and that the ray which disappeared ranged through 360°, as the tourmaline was turned through 180°, the rays of the cone being all polarized in different planes. Upon a more attentive examination he discovered the remarkable law, "*that the angle between the planes of polarization of any two rays of the cone is half the angle between the planes containing the rays themselves and the axis.*" The angle of the cone was found to be 6° 24′, 5° 56′, and 6° 22′; the mean of which is 6° 14′.

When the aperture was considerable, such as that formed by a large-sized pin, two concentric circles were seen to surround the axis, the inner one being nearly twice as bright as the outer one, and consisting of unpolarized light, while the outer one was polarized according to the preceding law. By using smaller apertures the inner circle grew less, until it became a point in the centre of the fainter exterior circle, which remained fixed. With a still less aperture a dark space sprung up in the centre, increasing as the aperture diminished, until, with a very minute aperture, the breadth of this central space increased to about three-fourths of the entire diameter. In these cases the appearances are as

Fig. 197. Fig. 198. Fig. 199.

shown in figs. 197 and 198. When the line joining the luminous point on the first surface was slightly inclined to the axis, the appearance was that shown in fig. 199.

Dr Lloyd observed an interesting variation in the phenomena by substituting a *narrow linear aperture* for the circular one on the first surface of the crystal, this aperture and the one in the plate next the eye being in the plane passing through the optic axes. The line had the appearance shown in fig. 200, swelling out into the form of an oval curve round the optical axis. By using a very minute aperture next the eye, the phenomenon was shown in fig. 201. When the plate next the eye was slightly shifted, so that the plane passing the aperture did not coincide with the plane of the optic axes, the curves rapidly changed, preserving, however, the form of the conchoid whose pole was the projection of the axis of the emergent

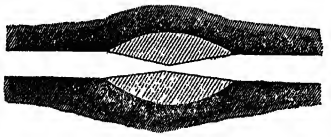

Fig. 200.

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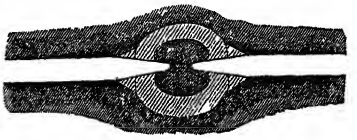

Fig. 201.

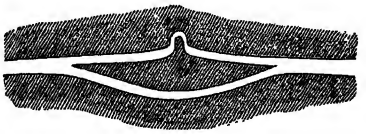

Fig. 202.

cone, and asymptote the line on the first surface. These effects are represented in figs. 202 and 203.

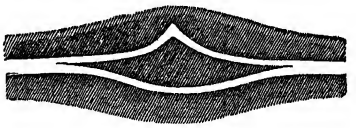

Fig. 203.

The second kind of conical refraction, deduced theoretically by Sir W. R. Hamilton, takes place when a single external ray is incident upon a biaxal crystal, so that one refracted ray coincides with an optic axis. In this case there should be a cone of rays within the crystal, the angle of the cone in arragonite being 1° 55′. As this cone will have its rays refracted at emergence, in a direction parallel to the incident ray, they will form a small cylinder of rays in air, the character of whose section by the surface of emergence being only 1° 55′ at a distance equal to the thickness of the crystal.

In order to detect the existence and measure the size of this cylinder, Dr Lloyd used the light of a lamp placed at some distance, and he made its light pass through two small apertures placed in a straight line, the one in a screen near the flame, and the other in a plate of metal close to the first circle of the crystal. Under ordinary circumstances, the incident ray will be doubly refracted within the crystal, and the two pencils will emerge parallel to the second surface. Dr Lloyd was able to distinguish these two pencils by means of a lens; and turning the crystal slowly, so as vary the incidence, he observed a position in which the two rays changed their relative places rapidly on any slight change of incidence, and appeared at times to revolve round one another as the incidence was changed. Being convinced that the ray was now at the critical incidence, Dr Lloyd changed the position of the crystal relative to the incident ray very slowly; and after much care in the adjustment, he at last saw the two rays spread into a continuous circle, and exhibit the phenomena which we have already described in his own words in our *History* of Optics.

Dr Lloyd measured the angle of the cone by an indirect method, and found it 1° 50′, differing only 5′ from the angle deduced from theory.[1]

Sect. XI.—On the Effect of Pressure and Heat on the Double Refraction of Crystals with One, Two, and Three Axes.

Influence of pressure.

The influence of pressure and heat in modifying the doubly-refracting structure of bodies that previously pos-

[1] See *Irish Trans.* 1833, vol. xvii.; and *Lond. and Edin. Phil. Mag.*, 1833, No. viii., p. 112, No. ix., p. 207.

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sessed that property, and of creating a new doubly-refractive structure in uncrystallized bodies, was first studied by Sir David Brewster.[1] By applying compressing and dilating forces to minerals, he succeeded in altering their doubly-refracting structure in every direction; but the effect was always most easily seen when it was produced along the real axis of uniaxal crystals, or the resultant axes of biaxal ones, where the effect of the natural forces was either nothing or compensated. The following were some of the results to which he was led by applying the forces to parallel surfaces.

Axis of Compression and Dilatation parallel to the Axis of the Crystal.

Positive crystals	Compressed	Tints rise in Newton's scale.
	Dilated	Tints descend in Newton's scale.
Negative crystals	Compressed	Tints descend in Newton's scale.
	Dilated	Tints rise in Newton's scale.

Axis of Compression and Dilatation perpendicular to the Axis of the Crystal.

Positive crystals	Compressed	Tints descend in Newton's scale.
	Dilated	Tints rise in Newton's scale.
Negative crystals	Compressed	Tints rise in Newton's scale.
	Dilated	Tints descend in Newton's scale.

The axis of compression and dilatation is the line perpendicular to the two surfaces pressed together or drawn asunder.

The above results were obtained by experiments both on uniaxal and biaxal crystals.

When the axis of compression was perpendicular to the axis of double refraction of a *uniaxal* crystal, it was partially converted into a biaxal one with two axes, *the poles of the two resultant axes being distinctly visible.*[2]

Influence of heat.

M. Fresnel was, we believe, the first person who observed the influence of heat in altering the *tints of sulphate of lime* perpendicular to the laminæ; but we are not able to refer to the details of his experiments. Professor Mitscherlich, however, has investigated the action of heat upon this mineral so completely as to include all previous experiments in his results. Having found that heat acts upon calcareous spar differently in different directions, expanding it in the direction of its axis, and slightly contracting it in directions perpendicular to the axis, he sought to determine if any variation in the double refraction was produced by heat. By the method of interferences, and observing the compensation produced by crossing plates of crystals at different temperatures, he observed that a change in the double refraction was produced.

Mitscherlich.

In extending these experiments, Professor Mitscherlich found that the two resultant axes of sulphate of lime inclined 60° to each other at common temperatures, approached each other when heated, till they met, and constituted one axis of double refraction. By increasing the heat they again separated *in a plane perpendicular to the laminæ*. In this experiment the principal axis of double refraction which bisected the optic axis gradually increased, while the second real axis perpendicular to the laminæ diminished and disappeared when the crystal assumed the uniaxal state. A new axis then sprung up in the plane of the laminæ perpendicular to the principal axis.

Sir John Herschel.

Sir John Herschel, in mentioning this remarkable experiment, states that he observed the tints of a plate of sulphate of lime *rise* rapidly in the scale when the plate was moderately warmed by the heat of a candle held at some distance below it, and sink again when the heat was withdrawn. He found, on the contrary, "that mica similarly heated undergoes no apparent change in the position of its axes, or in the size of its rings, though heated nearly to ignition."[3]

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Later experiments.

The extraordinary experiment of Professor Mitscherlich was repeated by Sir David Brewster with one of the specimens of sulphate of lime in which he discovered one of the resultant axes of this mineral. The following is the account which he has given of this experiment, and of the discovery of a still more curious property in *glauberite*:[4]—"The specimen of sulphate of lime was about $1\frac{1}{2}$ inch thick in the plane of the laminæ; and the system of rings which surrounded this axis was exceedingly minute, with the usual black brush at each end of them. The other system of rings could not be seen in this specimen, owing to the manner in which it was cut. Having brought the crystal to a considerable heat, and exposed it to polarized light, it was a singular sight to see the system of rings travelling along towards the line which bisects the optic axes, like a celestial body passing through the field of a telescope, and changing their form and size as they advanced. The specimen did not permit me to see the two systems unite, and still less to see them open out again in a plane at right angles to the laminæ; but from the degree of heat which I used, and which drove off the water of crystallization from part of the specimen, I presume that the complete phenomenon cannot be developed without destroying the constitution of the crystal—that is, that after the two systems of rings have opened out in a new plane, they will not return, by cooling, through their state of union, into their primitive inclination of 60° in the plane of the laminæ.

"A similar property I discovered in *glauberite*. This mineral has at ordinary temperatures the curious property of *two axes of double* refraction for *red* light, and only *one axis* for *violet* light. If we apply heat to it, the two optic axes for red light gradually close, and at a temperature which the hand can endure, the two systems of rings for red light have united into one system, so that the crystal has now only one axis of double refraction for red light. By continuing to increase the heat, the two axes separated, and the single system of rings opened out into two systems, lying in a plane at right angles to that in which they were placed at first. The heat was now less than that of boiling water. By increasing it, the inclination of the optic axes gradually increased.

"I now applied artificial cold to a crystal of glauberite at the ordinary temperature of the atmosphere. The inclination of the optic axes for red light increased, as might have been predicted; but, what was very unexpected, a *new axis was created for violet light*, the plane of the two violet axes being coincident with the plane of the two red optic axes at and below the ordinary temperature. An increase of cold increased the inclination of the optic axes for all the colours of the spectrum; the inclination of the axes being *least* for the *most refrangible*, and *greatest* for the least refrangible rays.

"These results appear very complicated when we begin with the effects at an ordinary temperature, and view them in the manner in which they were observed; but if we commence the experiments at a low temperature, such as the freezing point, the order and connection of the phenomena will be more easily understood.

"At 32° glauberite has two axes of double refraction for rays of all colours, the inclination of the axes for the violet

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[1] *Phil. Trans.* 1815, pp. 1, 60; 1816, p. 167; and *Edin. Trans.*, vol. viii., p. 281.
[2] *Edin. Trans.*, vol. viii., p. 285.
[3] *Treatise on Light*, sect. 1113.
[4] *Lond. and Edin. Phil. Mag.*, Dec. 1832, vol. i., p. 417.

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rays being least, and that for the red the greatest. As the temperature rises, the optic axes for all colours gradually approach, and the axes for violet first unite into one. At this time the crystal has two axes for all the other colours; but as the heat increases, all the other pairs of axes unite in succession, and form a single system of rings. But before this has taken place, the axes for violet rays have opened up again in a plane at right angles to that in which they originally lay, and they are followed by all the other pairs of axes; so that at a temperature much below that of boiling water, each pair of axes appears with different inclinations arranged in a new direction.

"During all the changes which have been described above, the crystal has preserved its constitution; and by abstracting the heat, the phenomena are all repeated in an inverse order.

"If the crystal should happen to be observed at that temperature, which very often occurs, when the greenish-yellow or most luminous rays have the optic axes corresponding to them united, or form a single system of rings, then the blue rays will have two systems of rings lying in one plane, and the red rays also two systems of rings in a plane at right angles to this. In two rectangular positions—namely, when the planes of the double axes coincide with or are at right angles to the plane of primitive polarization, the black cross will be very distinct; but in intermediate positions it will be much less so, and the uniaxal system of rings which predominates, from the greater intensity of their light, will have that indistinctness of character which, whenever it occurs, indicates a peculiar action of the doubly-refracting force on the differently-coloured rays. When the black cross is perfect and equally distinct in all positions, while the colours of the rings deviate from those of Newton's scale, then the axes for all colours are obviously coincident, and the peculiarity in the colour of the rings is owing to an irrationality in the action of the doubly-refracting forces on the differently-coloured rays."

Professor Rudberg.

A series of highly valuable experiments on the changes which temperature produces in the double refraction of crystals,[1] were made by Professor Rudberg of Upsal. Professor Mitscherlich having only determined the ratio between the mean double refraction of Iceland spar in a cold and in a heated state, without ascertaining the separate variations in each pencil, Professor Rudberg was desirous of supplying this desideratum.

For this purpose he constructed a box AB, having four of its faces double, so as to inclose a space which received through the pipe P, and retained, the steam from a boiler. This space communicated also with the external air. The other two faces of the box were formed with plates of mica. The inner box, therefore, contained only air, which was heated by the surrounding steam. A thermometer T indicated the temperature of the air. A tube R, passing through the two lower surfaces of the box, formed a free communication between the interior and the exterior air, so that their elasticity was the same. Through this tube R, without touching its sides, there rose from the centre of the repeating circle a vertical copper rod, carrying a plate C, upon which the crystal was placed. This rod was attached below to another plate of copper, which rested on a ring of copper, which, having teeth upon its circumference, could be moved by a screw. By this arrangement he could perform the experiments as readily as if there had been no heating apparatus to obstruct them. The heating apparatus was attached by a rod Q of iron rising from the masonry on which the repeating circle rested.

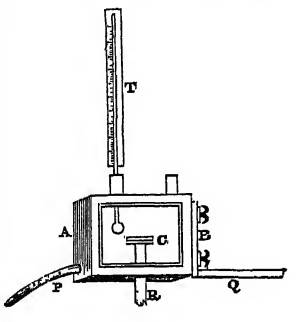

Fig. 204.

Polarization.

The experiments were made to determine the index of refraction of the ray F of Fraunhofer's spectrum near the boundary of the *green* and *blue* spaces. In this way he obtained the following results:—

Calcareous spar.

1. CALCAREOUS SPAR.—Refracting angle of prism 59° 55′ 9″.

a. Ordinary Ray.—The minimum deviation of the line F produced by the prism was 52° 53′ 43″. With a difference of temperature of 64° (Reaumur we presume), this ray suffered no change in its deviation; from which Prof. Rudberg concluded *that the refractive power of* CALCAREOUS SPAR *for the ordinary ray either does not change at all with the temperature*, or decreases with it by a quantity *extremely small*. The index of refraction of F at the ordinary temperature was 1·66802.

b. Extraordinary Ray.—By the difference of temperature of 64°, the deviation was increased 2′ 26″, or 2′ 34″ when corrected, which gives for the index of refraction

1·49118 at 64°
1·49075 at ordinary temperature.

0·00043 increase.

Hence, *in the extraordinary ray a rise of temperature of* 64° increases the index of refraction 0·00343.

Professor Rudberg confirmed this result in the presence of Professor Mitscherlich in 1832.

Rock-crystal.

2. ROCK-CRYSTAL.—Refracting angle of prism 45° 20′ 5″. In both the ordinary and extraordinary ray the deviation was *decreased* by a rise of temperature 42″. The indices for the ray F became in the extraordinary ray 1·55868, being 0·00028 more than at the ordinary temperature; and in the ordinary ray 1·54944, being 0·00026 less.

Arragonite.

3. ARRAGONITE.—With four prisms he obtained the following results:—

	Prism No. 1.	No. 2.	No. 3.	No. 4.
Variation of the deviation...	−5′ 8″	−1′ 53″	−4′ 3″	−2′ 58″
Variation of refracting angle	−0 0	+0 16	−1 53	−0 48·6

When corrected for the deviation of the plate of mica, they became

	No. 2.	No. 3.	No. 4.
Variation of deviation.....	− 1′ 47″	−3′ 57″	−2′ 52″
Variation of angle.....	+30 0	−1 44	−0 40

Hence he obtained the following indices of refraction:—

	No. 2.	No. 3.	No. 4.
At ordinary temperature.....	1·53478	1·69510	1·69058
At increased temperature.....	1·53416	1·68421	1·68976
Changes on index.....	−0·00062	−0·00089	−0·00082

Regular double refraction produced by pressure.

While heat and pressure thus modify the doubly-refracting structure in minerals, they are capable of creating it with *regular axes* in several soft substances. This effect is quite different, as we shall soon see, from that which is produced upon bodies by pressure, where the result is modified by the external form of the body, and where the double refraction disappears when the heat or pressure is removed, or when the body is subdivided. A permanent change is induced upon the soft solids in question, and, when subdivided, each part of the mass or plate preserves the property communicated to it. Sir David Brewster described, in the *Philosophical Transactions* for 1815, the original experiment which he made on this subject with a mixture of rosin and white wax; but in the same work for 1830 he has given a detailed account of his experiments

[1] This interesting paper was communicated by the author to Sir David Brewster, and published in the *Lond. and Edin. Phil. Mag.*, Dec. 1832, vol. i., p. 409.

Polarization.

and of the conclusions to which they lead respecting the origin of the doubly-refracting structure. The following is the fundamental experiment described by our author:—

"I took a few drops of the melted compound (rosin and bees'-wax), and placed them in succession on a plate of thick glass, so as to form a large drop. Before it was cold I laid above the drop a circular piece of glass about two-thirds of an inch in diameter, and, by a strong vertical pressure on the centre of the piece of glass, I squeezed out the drop into a thin plate. This plate was now almost perfectly transparent, as if the pressure had brought the particles of the substance into optical contact.

"If we expose this plate to polarized light, we shall find that it possesses one *positive* axis of double refraction, and exhibits the polarized tints as perfectly as many crystals of the mineral kingdom. The structure thus communicated to the soft film by pressure does not belong to it as a whole, nor has it only one axis passing through its centre, like a circular piece of unannealed glass. In every point of it there is an axis of double refraction perpendicular to the plates, and the doubly-refracting force varies with the inclination of the incident ray to this axis, as in all regular uniaxal crystals.

"When the two plates of glass are drawn asunder, we can remove one or more portions of the compressed plate, and these portions act upon light exactly like plates of uniaxal mica or hydrate of magnesia, and develop a double-refracting force of nearly equal intensity."

Cause of double refraction.

By reasoning from this experiment, our author is led to the opinion that double refraction is acquired by the particles of bodies at the instant of their aggregation, and arises from the pressures produced in the direction of three rectangular axes, by the forces of aggregation. When these forces are very weak, double refraction will not be produced; when they are sufficiently strong and of equal intensity, they will produce tessular crystals; when they are equal in two rectangular directions, they will produce uniaxal crystals; and when they are unequal in all the three directions, they will form biaxal ones. In this way all the phenomena of cleavage may be readily explained.

Upon some substances heat performs the same part as pressure; but our limits will not permit us to detail the experiments of Sir David Brewster on this subject.

Sect. XII.—On the Deviation of the Polarized Tints from those of Newton's Scale.

In all his investigations respecting the colours of thin plates, M. Biot happened to use only such crystals as gave polarized tints similar to those of Newton's scale, and he therefore considered this to be their character. In 1813, however, when Sir David Brewster described the rings in topaz, he not only found these colours to vary in different azimuths in the same ring, but observed some colours at the extremity of the optic axes. In his paper on the Laws of Polarization, in the *Philosophical Transactions* for 1818, he remarks, that "in almost all crystals with two axes, the tints in the neighbourhood of the resultant axes, when the plate has a considerable thickness, lose their resemblance to those in Newton's scale."

In examining the colours of the polarized rings in biaxal crystals, he was led to divide them into two classes, viz.,—

1. Those that had the *red* ends of the rings *inwards*, or between the resultant axes, and the blue ends *outwards*.

2. Those that had the red ends of the rings *outwards*, and the *blue* ends of the rings *inwards*.

The crystals in which the deviation is very striking are given in the following table:—

Polarization.

Class 1.—*Red ends inwards.*

Nitre.	Carbonate of lead.
Sulphate of barytes.	Sulphato-bicarbonate of lead.
„ of strontites.	Hyposulphate of strontia (Herschel).
Tartrate of potash and soda.	Tartrate of potash.
Phosphate of soda.	
Arragonite.	

Class 2.—*Red ends outwards.*

Topaz.	Native borax.
Mica.	Sulphate of magnesia.
Anhydrite.	Arseniate of soda.

Unclassed.

Chromate of lead.	Superoxalate of potash.
Muriate of mercury.	Oxalic acid.
„ of copper.	Sulphate of iron.
Oxynitrate of silver.	Cymophane.
Sugar.	Felspar.
Crystallized Cheltenham salts.	Benzoic acid.
	Chromic acid.
Nitrate of mercury.	Nadelstein.
„ of zinc.	Hyposulphate of soda (Herschel).
„ of lime.	

In examining the rings formed by biaxal crystals, Sir David Brewster found that the black spot at the point of compensation was not in the centre of the rings, and the position of this spot for *topaz* is given in his table of these colours. (*Phil. Trans.* 1814, p. 204.)

Sir John Herschel's experiments.

It is to Sir John Herschel, however, that we owe the complete investigation of this subject. By using homogeneous light, he found that the angle of the resultant axes POp, POp′ (fig. 159) was different for the different colours of the spectrum, varying, in the case of *tartrate of potash and soda*, from 75° 42′ in *red* light to 55° 14′ in *violet* light; so that with *white* light we have a system of rings consisting of five rings of all colours overlapping each other, and these five constituting an irregular system, unlike those produced by ordinary crystals.

In crystals where the displacement of the rings is great, the *oval central spot* seen in figs. 183, 184, and 185, are drawn out, as Sir John Herschel remarked, into long spectra or tails of *red*, *green*, and *violet* light, and the extremities of the rings are distorted and highly coloured, as in fig. 205. When we view these spectra with coloured media, they are

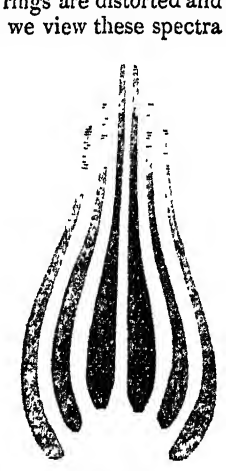

Fig. 205.

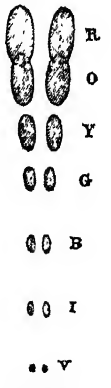

Fig. 206.

found to consist of well-defined spots of the several simple colours, arranged on each side of the principal section, as shown in fig. 206.

These results are capable of being rigorously calculated by the law of resultant axes given by Sir David Brewster, and may be considered as a proof of that law. If this were not the case, *tartrate of potash and soda* would have two axes for every different ray of the spectrum, and four series of poles extending each over a space of *ten degrees*.

Polarization.

In order to show how these phenomena may be calculated by two axes, let O and A (fig. 207) be two negative axes, which in *red* light compensate each other at F and F'; then, if O and A had the same proportional action on the *violet* and other rays as on the *red* rays, F would also be the point of compensation for the *violet* and other rays. In this case F would be the centre of all the systems of rings, as in uniaxal crystals, and the tints those of Newton's scale.

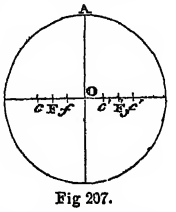

Fig 207.

But if the axis O has a greater proportional action upon the violet and other rays than A, the point of compensation will be at *f*, which will be the centre of the violet system of rings, the centres of all the other systems being between F and *f* if the action of O upon them is of an intermediate nature. This is the case with all the crystals in Class 1 of the foregoing table. On the other hand, if O has a less proportional action on the violet than on the red, *c*, *c* will be the points of compensation for the *violet* rays, and the centres of the two systems of violet rings.

Apophyllite.

The most remarkable instances of deviated tints are those discovered by Sir David Brewster in *apophyllite*, a crystal with one axis. Sir John Herschel, in examining a number of apophyllites, found that some specimens exercise *negative* action upon the rays at one end of the spectrum, a positive action upon rays at the other end, and no action at all upon the mean refrangible rays, the doubly-refracting action ceasing in the one case in the yellow rays, and in another in the indigo. In other specimens, the diameter of the rings was nearly the same for all the colours of the spectrum, and hence the rings were approaching to a series of black and white ones. All these phenomena may be separately calculated by the law of resultant axes already mentioned, on the supposition that apophyllite has three rectangular axes of double refraction. Sir David Brewster had discovered in the tesselated apophyllite portions which had *two* axes co-existing with portions that had *one* axis; and in his coloured drawings of the phenomena exhibited by this mineral, he has pointed out a most extraordinary law of symmetry which regulates its varying double refraction; and as he had shown that a double dispersive power existed in the same crystal, the following explanation of the remarkable phenomena of apophyllite approaches to the character of demonstration.

Let O (fig. 208) be the positive axis of uniaxal apophyllite, and let A and B be two *positive* axes which, if equal, would produce a *negative* axis at O. But as the real axis at O is a positive one, the apparent or finally resultant axis at O will be a single axis, *negative* if the *negative* is the strongest, and positive if the positive is the strongest. Let us now suppose that the two axes at O have equal intensity, —viz., $+O = -O$ for *yellow* light ($-O$ being the resultant of $+A$ and $+B$), and that $-O$ acts more powerfully upon the *red* rays than $+O$, while $+O$ acts more powerfully upon the *violet* rays. In this case, the two axes $+O$, $-O$ will exactly compensate each other. In *yellow* light a yellow ray will experience neither double refraction nor polarization; whereas in *red* light, the predominance of $-O$ will leave a single negative axis for *red* rays, and produce a *negative* system of rings; and in *violet* light the predominance of $+O$ will leave a single *positive* axis of double refraction for violet rays, and consequently a *positive* system of rings. This compensation resembles that of a compound lens, consisting of a *convex* and *concave* lens of equal curvature, of such a glass that their refractive index for *yellow* light is equal, while the index of refraction for the *violet* rays is *greater* in the *convex* lens, and the index for the *red* rays *greater* in the *concave* lens. Such a lens will *converge* the *violet* rays, *diverge* the *red rays*, and *produce no deviation* at all in the *yellow* ones,—that is, the same compound lens will be a *plane* lens in *yellow* light, a *convex* one in *blue* light, and a *concave* one in *red* light. Hence each order of colours in apophyllite is, as it were, a secondary or residual spectrum arising from the opposite action of unequal negative and positive axes. From the fact of some apophyllites exercising a negative action, Sir David Brewster stated his expectation that apophyllites might be found in which the double refraction is negative for all the rays of the spectrum; and several years afterwards he discovered the remarkable mineral of *oxahverite*, which is an apophyllite with this property. (*Edinburgh Journal of Science*, No. xiii., p. 115.)

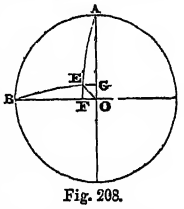

Fig. 208.

Polarization.

Sect. XIII.—On Crystals with Planes of Double Refraction exemplified in Analcime.

Analcime.

Analcime or *Cubizite*, a mineral ranked among the cubical crystals, was found by Sir David Brewster to be a singular body in its action upon light, and to exhibit the extraordinary property of many planes of double refraction, or planes to which the doubly-refracting structure was related in the same manner as it is to *one* or *two* axes in other minerals.

It crystallizes most commonly in the form of the *icositetrahedron*, as in fig. 209. If we suppose a complete crystal of it to be exposed to polarized light, it will give the remarkable figure shown in fig. 209, where the dark shaded lines are planes in which there is neither double refraction nor polarization, the double refraction and the tints commencing at these planes, and reaching their maximum in the centre of the space inclosed by three of the dark lines. The tints are those of Newton's scale, and are negative in relation to each of the four axes of the *icositetrahedron*. When light is transmitted through any pair of the four planes which are adjacent to any of the three axes of the solid, it is doubly refracted, the least refracted image being the extraordinary one, and consequently the double refraction negative in relation to the axes to which the doubly-refracted ray is perpendicular.

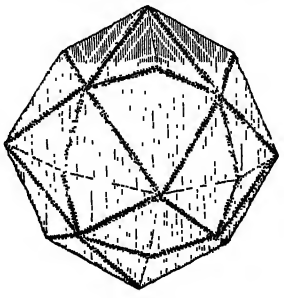
Fig. 209.

If we suppose the crystal to have the form of a *cube*, the planes of double refraction will be, as in fig. 210, a plane passing through the two diagonals of each face of the cube.

The tints vary as the square of the distance from the nearest plane of double refraction.

The tints shown in figs. 209 and 210 cannot of course be seen at the same time, but are deduced from observations made by transmitting polarized light in every direction through the crystal.

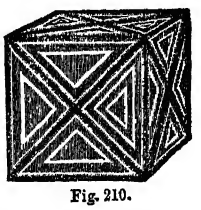
Fig. 210.

Sect. XIV.—On the Double Refraction and Polarization of Composite Crystals.

Composite crystals.

In all the crystallized bodies whose action upon light we have been considering, excepting *analcime*, the phenomena are identical in all parallel directions, the smallest fragment having the same property as the largest, from whatever part of the crystal it is taken.

In the mineral world, however, and among the products

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of artificial crystallization, there occur crystals which are composed of several individual crystals whose axes are not parallel. These crystals sometimes occur in such regular symmetrical forms, that mineralogists have long regarded them as simple forms; and it is probable that they would have still been viewed in this light if they had not been exposed to the scrutiny of polarized light.

One of the most remarkable of these composite crystals is Iceland spar, some specimens of which were observed, even by Bartholinus and Huygens, to exhibit phenomena quite different from those already described.

Malus describes the phenomena as produced by fissures parallel to the surface of the variety of this mineral described by Haüy under the name of *chaux carbonatée equiaxe*. He explains the duplication of the images on the supposition that there is a *fissure* or real opening between the conjoined faces of the spar, and he ascribes the varying tints to a cause not adequate to the production of such splendid phenomena,—to the colouring of the thin plate of air included in the fissure.

This class of phenomena was particularly investigated by Sir David Brewster, who found that the fissures described by Malus *were thin crystallized laminæ of Iceland spar*, having their axes of double refraction inclined to that of the portions of the crystal which it separated; that these laminæ varied in thickness, the thinnest producing a large system of rings, and the thicker plates smaller systems, the plates being sometimes so thick that no colours whatever appeared. Hence it was obvious *that each crystal of this kind was a polarizing and an analysing apparatus, the thin laminæ being the plate which exhibited its polarized tints in this singular position.*

In order to understand this remarkable structure, we have represented the laminæ in fig. 211 by the planes ABCD, *ebcg*, *afhd*, parallel to the edges EG, FH, and also to the long diagonals of the rhomboidal faces, or perpendicular to the short diagonal EF. When we look through a crystal with only *one* of these laminæ, we observe the two principal images of the candle A, B, or luminous body (fig. 212), while at a vertical incidence and separated just as they would have appeared in a common crystal of the same thickness. But on each side of this double image is a single-polarized image C and D, C being polarized in the same plane as B, and D in the same plane as A. Let us suppose that these phenomena are seen through a rhomb with only one plane ABCD (fig. 211), and through the faces EADG, BFHC. Then, if we incline the rhomb in different directions slightly, we shall see the images C, D disappear when they have a certain distance from A, B. If we incline the rhomb, bringing EA nearer the eye than GD, the images C, D will approach to A, B, and the disappearance will be found to take place nearer and nearer to A, B as the inclination is increased, it being necessary to bring the edge EG nearer the eye than AD, to make C and D disappear. While C and D are thus approaching to A, B, they become less and less coloured till they are all white. If we incline the rhomb in an opposite direction, so that GD is brought nearer the eye than EA, the images C, D recede from A, B, and become more highly coloured, the two images A, B becoming also coloured. The images C, D sometimes appear doubled when this inclination is going on, but it is only a duplicity of colour, so to speak, in consequence of the spectrum being divided by portions of it passing into the reflected pencil. When we bring EG nearer the eye than AD, the colours increase, A and B become also coloured, and an apparent colorific duplication of the images C and D takes place. If the rhomb is inclined in an opposite direction, so that AD is brought nearer the eye than EG, the images C, D become also at first more coloured; but by increasing the inclination, the image C recedes rapidly on the right side from A, B, contracts in breadth, and becomes prismatically coloured, the spectrum which it exhibits being subdivided by several black lines or bands, the parts of the spectrum corresponding to these black lines or dark bands having passed into the reflected ray. The spectrum D recedes as rapidly to the left, expanding in breadth, and even disappearing, as well as the images A, B.

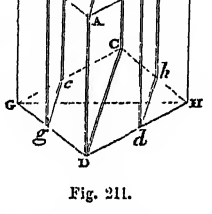

Fig. 211.

Fig. 212.

All these phenomena are more finely seen, and the law of their changes more easily detected, if, instead of a candle, we look at a long line of light, such as the narrow opening between the edges of the window-shutters.

If we look through the faces ADHF, CBEG of the rhomb, placing a prism of glass with an angle of 12° or 15° upon one of the faces, to permit the refracted rays to emerge at a moderate angle of deviation, the prismatic images formerly described will be large spectra, subdivided by black spaces into 4, 5, 6, &c., coloured images of the candle, or of the long luminous line, exhibiting one of the most magnificent phenomena that can be witnessed.

These phenomena vary, of course, with the thickness of the inclosed laminæ, and as the laminæ increase in thickness the subdivisions of the spectral images become more numerous.

When we reflect light from these laminæ ABCD, for example, by allowing the light to enter by the face BFHC, and emerge through the face AFHD, the boundary of total reflection is marked by a series of brilliant rectilineal fringes, polarized in the same manner as the image C, which is now the lowermost. When the light is transmitted through the laminæ at the boundary of total reflection, by entering through the face BEGC, and emerging through AFHD, a series of rectilineal fringes complementary to the former reflected series is seen. They also are polarized in the same plane as C, or the lowermost secondary image, and become much more distinct, by causing the oppositely-polarized pencil to disappear.

The structure which produces the preceding phenomena, and the duplication of the images, will be understood from fig. 213, where ABDC is the principal section of a crystal of this kind of Iceland spar, having AD for its axis. One of the laminæ oppositely crystallized is shown at M*m*, N*n*, but much thicker than they are generally, the angles A*m*M, D*n*N being 141° 44′. A ray of ordinary light R*b* will be refracted in the lines *bc*, *bd*. These rays entering the lamina MN, will be again refracted doubly; but as the vein is so thin as to produce the system of uniaxal rings, the colours will vary with the thickness of the film and the inclination of the ray to the axis of the lamina. The four pencils will emerge from the lamina at *e*, *f*, and will be refracted again, as in the figure, into the pencils *em*, *en*, *fo*, *fp*, the colours of *en*, *fo* being complementary to those of *em*, *fp*.

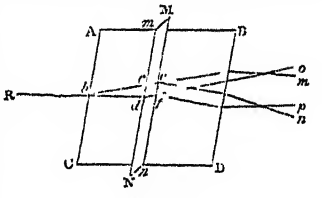

Fig. 213.

That the multiplication and colour of the images are produced by the causes above explained has been proved by Sir David Brewster, by actually placing laminæ of different crystals between the prisms AN, BN. In this way, by introducing different films in different azimuths, most beautiful combinations may be produced.

If we grind down the angles A and B, so as to have two

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faces perpendicular to the axis AB, the uniaxal system of rings is beautifully modified by the action of the lamina MN; and that this was the cause of the singular transformations which the rings experienced in different crystals, was proved by the author above quoted, by inserting laminæ between two plates of the *chaux carbonatée basée* of Haüy, whose natural faces are perpendicular to the axis.

Modifications of the rings in Iceland spar.

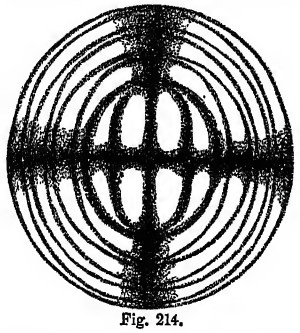

Fig. 214.

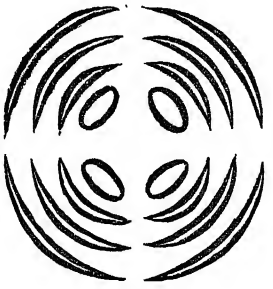

Fig. 215.

These transformations are exceedingly beautiful. Some of them are shown in figs. 214, 215, and 216, one of the rings consisting of eight dark radii, while the complementary system has its inner circle marked with *eight* dark-coloured spots. These rings suffer beautiful changes, both by the motion of the plane round its axis when the analysing plate is stationary, and by the motion of the analysing plate when the rhomb is stationary. In studying these phenomena in a great variety of crystals intersected with one or more laminæ, Sir David Brewster noticed a very remarkable fact. A rhomb of spar which produced in one part of it the transformed systems already mentioned, exhibited a singular effect in another part, where *the crystallization appeared perfect and simple*, and where there were decidedly no veins or laminæ. In one position or azimuth of this crystal this portion gave, as might have been expected, the regular system of rings with the black cross shown in fig. 179. But upon turning it round 45°, all the rings became *elliptical*, as shown in fig. 217, the *first* order of colours in one quadrant having joined the *second* order of colours in the adjacent quadrant. The arms of the black cross took the contorted position *abc*, *def*, the continuations of it afterwards,—viz., *am*, *cn*, *do*, *fp*,—being so very faint as to show the continuity of the elliptical rings. In this figure the rings of the same order are marked with the same figure. The very same phenomenon, which points to important theoretical consequences, was observed by the same author in another rhomb of spar *wholly without veins*, but the rings were not so elliptical as in fig. 217.

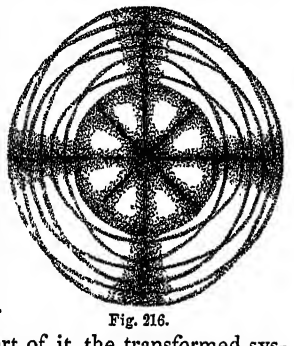

Fig. 216.

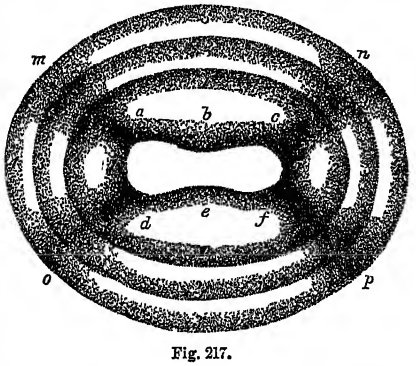

Fig. 217.

This composite structure was discovered by Sir David Brewster in various minerals, and he has described it very minutely in the case of *Brazilian topaz*, *sulphate of potash*, and *apophyllite*.

Sir John Herschel, we believe, first noticed this structure in Brazilian topaz, and observed that the central portion of the crystal had a different colour from the external portion, and that the plane of the principal section of the different parts made angles of 20° ±. Sir David Brewster found very remarkable arrangements of the coloured portions, which he has represented in coloured drawings in the Cambridge *Transactions*, vol. ii. In some of these crystals the structure was tesselated, as in fig. 218, where ABED, CBEF are the two external tesselæ, at one of the obtuse angles of the rhomboidal section. If we suppose that these tesselæ are divided into *four* laminæ, 1, 2, 3, 4, and that MN is the principal section, or one of the neutral axes of the central portion of the crystal contiguous to DEF, then the laminæ 1, 1 have their principal section in the direction *aa'* forming a very small angle with MN; the laminæ 2, 2 have their principal section in the line *bb*, and so on to the superficial laminæ 4, 4, which have their principal section in the direction *dd'*, inclined from 10° ± to 22° ± to MN, the inclination varying in different crystals. The lines *aa'*, *bb'*, &c., are also the principal sections of the corresponding laminæ on the side NC. In like manner, the principal sections *aa'*, *ββ'*, &c., of the laminæ in BCFE, are the principal sections of the corresponding laminæ on the other side AN. As the laminæ, however, are infinite in number, the principal sections have every possible direction between *dd'* and δδ.

Polarization.

Brazilian topaz.

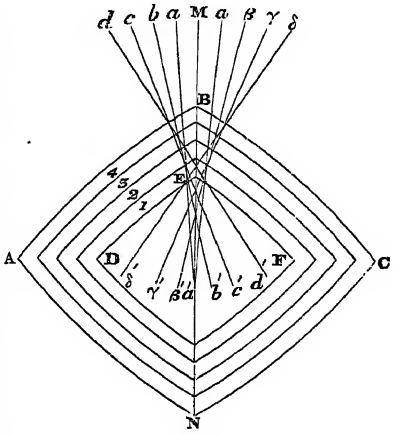

Fig. 218

Sulphate of potash.

The *bipyramidal sulphate of potash*, which Count Bournon supposed to be a simple crystal, was found by Sir David Brewster to be a tesselated crystal, composed of three pair of crystals of the prismatic sulphate of potash combined so that each pair had their principal axis parallel. When exposed to polarized light, each pair gave the system of biaxal rings, and when held at a distance from the eye, had the tesselated appearance shown in fig. 219, each opposite pair of the triangles having the same tint. (*Edin. Phil. Journal*, vol. i., p. 1).

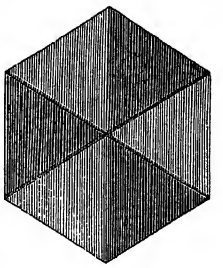

Fig. 219.

Apophyllite.

The most remarkable of this class of minerals, and indeed the most remarkable body in the whole mineral kingdom, is the *tesselated apophyllite*. It crystallizes most commonly in four-sided rectangular prisms, like CD (fig. 220). If we remove the uppermost slice A and the undermost B to the thickness of between the 50th and the 100th of an inch, and examine it either by the microscope or by polarized light, we shall find that it is like other uniaxal plates, giving a single system of rays having the very peculiar colours which have been already described. A number of veins appear at the edges, as shown in the figure. All the other slices lying below this exhibit the beautiful tesselated figure shown in fig. 221.

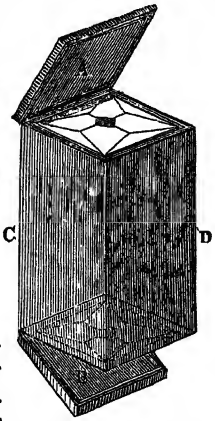

Fig.

Polarization.

The outer case MONP, which, as it were, binds together the internal portions, consists of a great number of parallel veins or plates, which give the colours of grooved surfaces. This frame incloses *nine* different crystals,—namely, the central lozenge *abcd*, the *four* prisms A, B, C, D with trapezoidal bases, and the *four* triangular prisms *ehl*, *lmn*, *nkg*, *gfe*, all of which are separated by distinct lines or veins, which are nearly all visible by the microscope by a proper method of illumination. In polarized light they are all seen with great facility.

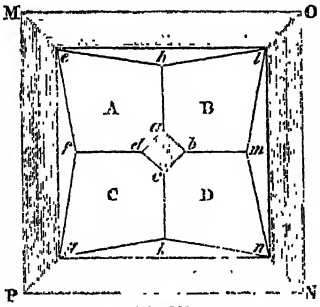

Fig. 221.

The most extraordinary fact connected with this structure is, *that the central lozenge has only* ONE *axis of double refraction, like the terminal plates* A, B (fig. 220), *while the four prisms* A, B, C, D, *and the four triangular spaces, have* TWO *axes.* In A and D the planes of the resultant axes are coincident, as in the opposite triangles of sulphate of potash, and lie in the direction MN, while the planes of the resultant axes in B and C lie in the direction OP.

When the plate MONP is exposed to polarized light and turned round its axis before the analysing plate, the lozenge *abcd* will be dark in every position of the plate, while the portions A, B, C, D, will depolarize the light, or be luminous, when MO or ON are parallel or perpendicular to the plane of primitive polarization.

Remarkable as is the structure which we have now described, it is greatly excelled in beauty by another variety of Faroe apophyllite, in which Sir David Brewster discovered the most extraordinary organization. He has given an enlarged coloured drawing of the fine symmetrical tints which it exhibits in polarized light, in the Edinburgh *Transactions;* but we hope its structure may be understood by the following description which he has given of it. The crystals have a greenish-white tinge, and are aggregated together in masses. The quadrangular prisms are in general below one-twelfth of an inch in width; they are always unpolished on their terminal planes; they have the angles at the summit more deeply truncated than the other quadrangular prisms from Faroe; they are always perfectly transparent; and may sometimes be detached in a complete state, with both their terminal summits.

"In examining this variety of apophyllite I was enabled, by the perfection of the crystals, to study their structure through the natural planes, and at right angles to their axes.

"When a complete crystal is exposed to polarized light, with its axes inclined 45° to the plane of primitive polarization, and is subsequently examined with an analysing prism, it exhibits, through both its pair of parallel planes, the appearance shown in fig. 222. In turning the crystal round the polarized ray, all the tints vanish, reappear, and reach their maximum at the same time, so that they are not the result of any hemitropism, but arise wholly from a symmetrical combination of elementary crystals possessing different primitive forms and different refractive and polarizing powers. The difference in the polarizing powers is well shown by the variation of tint; and the difference of refractive power may be observed with equal distinctness by examining the crystal with the microscope under favourable circumstances of illumination, when the outlines of the symmetrical forms shown in fig. 222 will be clearly visible.

"In examining the splendid arrangement of tints exhibited in the figure, the perfect symmetry which appears in all its parts is particularly remarkable. The existence of the curvilineal solid in the centre—the gradual diminution in the length of the circumscribing plates, in consequence of which they taper, as it were, from the angles of the central rectangle to the truncated angles at the summits—but, above all, the reproduction of similar tints on each side of the central figure, and at equal distances from it, cannot fail to strike the observer with surprise and admiration.

Polarization.

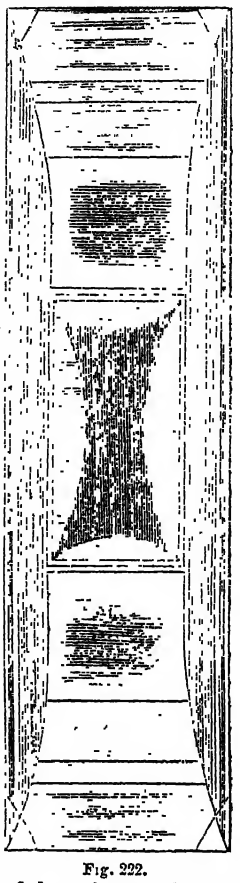
Fig. 222.

"The tints exhibited by each crystal vary, of course, according to its thickness; but the range of tint in the same plate, and at the same thickness, generally amounts in the largest crystals to three of the orders of colours in Newton's scale. The central portion, and the two squares above and below it, have in general the same intensity, while the four segments round the central portion, and some of the parts beyond each of the squares, are also isochromatic. In the central part the colours have a decided termination; but towards the summit of the prism their outline is less regular, and less distinctly marked, though this irregularity has also its counterpart at the other termination. A part of these irregularities is sometimes owing to the longitudinal striæ on the natural faces of the crystal, so that by carefully grinding these off the beauty and regularity of the figure is greatly improved.

"In order to ascertain the order of the colours polarized by the crystal, and observe in what manner they passed into one another, I transmitted the polarized light in a direction parallel to one of the diagonals of the quadrangular prism, and thus obtained, as it were, a section of the different orders of colours from the zero of their scale. The result of this experiment, which is shown in fig. 223, was highly interesting, as it displayed to the eye not only the law according to which the intensity of the polarizing forces varied in different parts of the crystal, but also the variation in the nature of the tints, and the connection between these two classes of phenomena. At the points in the diagonal *mn* opposite to *b*, *a* of the crystal, the tints rose to the *seventh* order of colours; and in other two places opposite to *c*, *d*, they were only to the *sixth;* while near the summits at *m*, *n* they descended so low as the *fourth* order. Hence it follows that the four curvilineal segments (fig. 222) are next to these in intensity; that the central portions of the squares are again inferior to these; and that the weakest polarizing force is near the summit of the prisms. At *a*, *b* the *fourth*, *fifth*, and *sixth* fringes have a singularly serrated outline, exhibiting in a very interesting manner the sudden variations which take place in the polarizing forces of the successive laminæ.

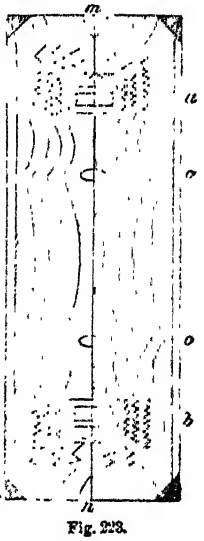

Fig. 223.

"Having thus described the structure and properties of the tesselated apophyllite, it becomes interesting to inquire how far such a combination of structures is compatible with the admitted laws of crystallography. The growth of a crystal,

Polarization.

in virtue of the aggregation of minute particles endowed with polarity, and possessing certain primitive forms, is easily comprehended, whether we suppose the particles to exist in a state of igneous fluidity or aqueous solution. But it is a necessary consequence of this process, that the same law presides at the formation of every part of it, and that tne crystal is homogeneous throughout, possessing the same mechanical and physical properties in all parallel directions.

"The tesselated apophyllite, however, could not have been formed by this process. It resembles more a work of art, in which the artist has varied not only the materials but the laws of their combination.

"A foundation appears to be first laid by means of a uniform homogeneous plate, the primitive form of which is pyramidal. A central pillar, whose section is a rectangular lozenge, then rises perpendicularly from the base, and consists of similar particles. Round this pillar are placed new materials, in the form of four trapezoidal solids, the primitive form of whose particles is prismatic; and in these solids the lines of similar properties are at right angles to each other. The crystal is then made quadrangular by the application of four triangular prisms of unusual acuteness. The *nine solids* arranged in this symmetrical manner, and joined by transparent veins performing the functions of cement, are then surrounded by a wall composed of numerous films, deposited in succession, and the whole of this singular assemblage is finally roofed in by a plate exactly similar to that which formed its foundation.

"The second variety of the tesselated apophyllite is still more complicated. Possessing the different combinations of the one which has just been described, it displays, in the direction of the length of the prism, an organization of the most singular kind. Forms unknown in crystallography occupy its central portion; and on each side of it particles of similar properties take their place at similar distances, now forming a zone of uniform polarizing force, now another increasing to a maximum, and now a third descending in the scale by regular gradations. The boundaries of these corresponding though distant zones are marked with the greatest precision, and all their parts as nicely adjusted as if some skilful workman had selected the materials, measured the spaces they were to occupy, and finally combined them into the finest specimen of natural mosaic."[1]

We have represented in figs. 224 and 225 the figure produced by polarized light by an internal slice of the barrel

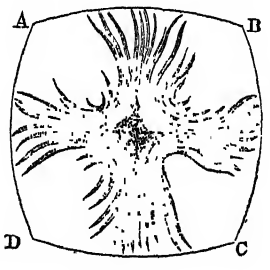

Fig. 224.

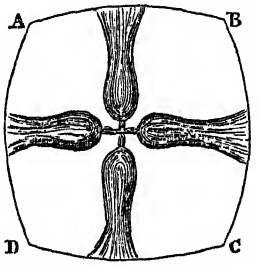

Fig. 225.

or cylindrical apophyllite from Kudlisaet, in Disco Island, brought home by Sir Charles Giésècke. The figures are from different specimens. The *shaded part of them has only one axis of double refraction*, while the *four sectors have two axes*, the luminous sectors being analogous to the prisms A, B, C, D, and the dark figure to the central lozenge *abcd*, in fig. 221. The mechanical structure of the cleavage planes resembles the optical figure even after the planes are ground. (*Edinburgh Transactions*, vol. ix., p. 328.) Polarization.

Sect. XV.—On the Absorption of Light by Uncrystallized Bodies.

Absorption of light by uncrystallized bodies.

When a beam of light passes through the most transparent media, such as air and water, a certain portion of it *is lost*. This loss of light is particularly apparent in such bodies when a beam of light has traversed a great thickness of the gas or the fluid. This loss of light has been called *absorption*, and the light lost is said to be *absorbed;* a term which we use at present merely to express a fact.

There are two kinds of absorption which may be noticed:—1. That in which all the rays of the spectrum are proportionally absorbed or lost; and, 2. That in which different quantities of the differently-coloured rays are lost. Those bodies in which the first kind of absorption takes place are *colourless*, and those in which the second kind takes place are *coloured*. In black *ink*, for example, the transmitted light of the sun is white. In red ink it is red, more of the most refrangible rays of the spectrum being lost than of the least refrangible ones.

When a beam of the sun's light falls upon a piece of charcoal the light is almost wholly lost or absorbed. Sir Isaac Newton thought that the light was reflected or refracted "to and fro" within such bodies till it was lost; but still the question meets us, Why is it lost? If it is scattered in all directions, it must emerge again from the charcoal and be visible in some way or other. In order to meet this and other difficulties, the light is supposed to be detained within the body, and somehow united to its substance.

In the case of red ink and similar bodies, Sir Isaac Newton conceived that the *blue* rays which were lost were reflected by the particles of the ink, while the red rays were transmitted, as in the colours of thin plates; but as we cannot by any process see these *blue* rays, we can only say that they are lost, and the cause of their loss is as difficult to be found as in the phenomena of imperfect colourless transparency.

The following are the general phenomena of coloured absorptions in transparent bodies:—

1. *Red* transparent solids or fluids absorb, generally speaking, the blue end of the spectrum.
2. *Blue* substances absorb, generally speaking, the red end of the spectrum.
3. *Green* bodies absorb both the blue and the red ends of the spectrum.
4. *Yellow* bodies absorb the *blue* and part of the *green* of the spectrum.

But when we examine more narrowly the action of coloured bodies on the spectrum, we find that a body may derive its peculiar tint from absorbing two, three, four, up to many hundred separate parts of the spectrum, so that the colour of such a body is the combination of all the parts of the spectrum which are not absorbed. We may infer, however, from the general tint of the body, what parts of the spectrum it has chiefly absorbed. *Red nitrous gas*, for example, must have acted most powerfully upon the blue end of the spectrum, as we have already seen that it does.

Two theories of absorption have been published by Sir John Herschel and Baron Wrede, founded upon the undulatory theory. Sir John Herschel conceives that light may be lost within bodies by the interference of different parts of a ray, which, after taking two routes of *different lengths*, meet again in a condition to interfere. Sir John Herschel.

[1] M. Biot has endeavoured, without success, to explain their structure by what he calls *lamellar polarization*. See sect. xx., art. viii., of the present chapter.

Polarization. Baron Wrede.

Baron Wrede supposes the particles of a transparent body placed regularly at equal distances, with the ether diffused between them. (See Taylor's *Scientific Memoirs*, part iii.) When a ray of light is propagated directly through this medium, a portion of it encounters some of the particles, and is reflected backwards, then forwards again, and emerges along with the direct ray, so that the reflected and direct portions will be in a state to interfere and destroy each other. This theory, which is analogous to Newton's, or rather the very same as Newton's, is liable to the objection we have already urged to every theory in which the light is supposed to be decomposed by interior reflections. Now, Baron Wrede's hypothesis may explain all the phenomena, such as dark bands and dark lines, which are known to be produced by thin plates of various thicknesses, as Dr Young has stated;[1] and it may even explain those bands and absorptions more recently discovered in decomposed glass by Sir David Brewster, where the effects are clearly produced by a combination of a great number of thin plates,[2] but where the reflected light is as copious as the transmitted light. But we cannot conceive it at all applicable to the cases of nitrous gas (to which he has attempted to apply it), and to solids and fluids, in which all attempts have failed to discover any of the reflected rays.

An important "connection between the phenomena of the absorption of light and the colours of thin plates" has been pointed out by Sir David Brewster, in a paper with that title.[3] This connection has been proved by a series of experiments made with *nacrite*, a kind of artificial mother-of-pearl (including thin plates in its substance), with films of decomposed glass, and with doubly-refracting plates, which give the colours of polarized light. In all these cases, but more especially in the experiments with decomposed glass, the characteristic phenomena of absorption are produced. Our limits will not permit us to describe the methods by which this result was obtained.

Colours of Two Images in Crystals with one Axis. Polarization. Uniaxal crystals.

Names of Crystals.	Colour when its Axis is in the Plane of Primitive Polarization.	Colour when its Axis is Perpendicular to that plane.
Zircon	Brownish-white	A deeper brown.
Sapphire	Yellowish-green	Blue.
Ruby	Pale yellow	Bright pink.
Emerald	Yellowish-green	Bluish-green.
Emerald	Bluish-green	Yellowish-green.
Beryl, blue	Bluish-white	Blue.
Beryl, green	Whitish	Bluish-green.
Beryl, yellow-green	Pale yellow	Pale green.
Rock-crystal almost transparent	Whitish	Faint brown.
Rock-crystal, yellow	Yellowish-white	Yellow.
Amethyst	Blue	Pink.
Amethyst	Grayish-white	Ruby-red.
Amethyst	Reddish-yellow	Ruby-red.
Tourmaline	Greenish-white	Bluish-green.
Rubellite	Reddish-white	Faint red.
Idocrase	Yellow	Green.
Mellite	Yellow	Bluish-white.
Phos. of lime (lilac)	Bluish	Reddish.
„ (olive)	Bluish-green	Yellowish-green.
Phos. of lead	Bright green	Orange-yellow.
Calcareous spar	Orange-yellow	Yellowish-white.
Octohedrite	Whitish-brown	Yellowish-brown.

Sir John Herschel has found this property beautifully displayed in the sub-oxysulphate of iron, which crystallizes in six-sided prisms. Along the axis the colour is a *deep blood-red*, while through the sides of the prism it is of a *light green* colour. Several tourmalines have also been observed by Sir John to have these same colours along the axis, and at right angles to it. There can be little doubt that this property will be found in every crystal of sufficient thickness that has the property of double refraction. Even if the crystal is colourless, a slight inequality in the intensity of the two images may be observed; and when it is distinctly coloured, the difference of intensity is very easily seen, even when the two colours are not of a different kind.

The phenomena of *dichroism* are best seen in crystals with *two* axes of double refraction, and are well exemplified in *iolite*, a mineral which crystallizes in six or twelve sided prisms. These prisms are of a *deep blue* colour when seen along the axis, and of a yellowish-brown colour when viewed in a direction perpendicular to the axis.

If *abcd* is a section of the prism of iolite in a plane parallel to the axis of the prism, the transmitted light will be *blue* through the faces *ab* and *dc*, and *yellowish-brown* through *ad*, *bc*, and in every direction perpendicular to the axis of the prism. If we grind down the angles *a*, *c*, *b*, *d*, so as to replace them with faces *mn*, *m'n'*, and *op*, *o'p'*, inclined 31° 41′ to *ad*, or to the axis of the prism; then, if the plane *abcd* passes through the resultant axes of double refraction, we shall observe, by transmitting polarized light through the crystal in the directions *ac*, *bd*, and subsequently analysing it, a system of rings round each of these axes. The system will exhibit the individual rings very plainly if the crystal is thin; but if it is thick, we shall observe, when the plane *abcd* is perpendicular to the plane of primitive polarization, *some branches of blue and white light, diverging in the form of a cross from the centre of the system of rings*, or the poles of no polarization, as

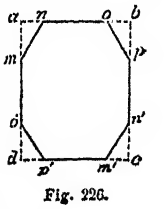

Fig. 226.

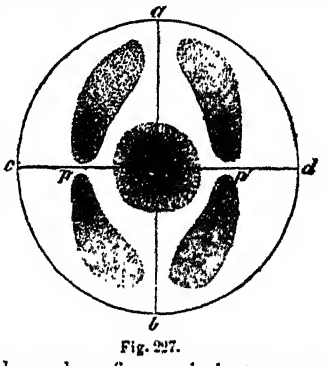

Fig. 227.

Sect. XVI.—On Dichroism, and the Absorption of Common and Polarized Light by Doubly-Refracting Crystals.

Dichroism.

The name of *dichroism*, or *double colours*, was given very appropriately, by M. Cordier, we believe, to a mineral called *iolite*, which in *common light* exhibited two different colours in different directions. Dr Wollaston and several mineralogists had observed this double colour in potash, muriate of palladium, tourmaline, and other crystals. The origin of this singular property was not known till Sir David Brewster investigated the subject in *iolite*, and showed that it was connected with the doubly-refracting structure, and never occurred in the *tessular* crystals which did not possess double refraction.

The connection of dichroism with double refraction, and its general laws, will be understood from the following observations. In a specimen of *yellow Iceland spar* the *extraordinary* image is of an *orange-yellow* colour, while the *ordinary* image is *yellowish-white*. Along the axis of double refraction the colour of the two pencils is exactly the same, and the difference of colour increases with the inclination of the refracted ray to the axis. Hence the difference of colour increases in proportion to the difference of the velocities of the two rays, and is consequently a maximum in the equator of double refraction, and is the same in all parallels; the colour along the axis being the natural colour of the mineral. This is the invariable law of the phenomena in uniaxal crystals. The following are the observations made by the author referred to:—

[1] *Elements of Nat. Phil.*, vol. i., p. 469. [2] *Phil. Trans.* 1837, part ii. [3] *Edin. Trans.* 1837, pp. 245–252.

Polarization. shown at p and p' (fig. 227), where the shaded branches represent the blue ones. The summits of the blue masses at p and p' are tipped with purple, and are separated by whitish light in some specimens, and yellowish light in others. The white light becomes more blue from p and p' to o, where it is quite *blue*, and more yellow from p and p' to c and d, where it is completely *yellow*. When the plane *abcd* is in the plane of primitive polarization, the poles p, p' are marked by spots of white light, but everywhere else the light is a deep blue.

In the plane *cadb* (fig. 227), the mineral, when we look through it at common light, exhibits no other colour but yellow, mixed with a small quantity of blue polarized in an opposite plane. The *ordinary* image at c and d is yellowish-brown, and the *extraordinary* image faint blue, the former receiving some *blue* rays, and the latter some *yellow* ones from c and d to a and b, where the difference of colour is still well marked. The *yellow* image becomes *fainter* from a and b to p and p', till it changes into *blue*, and the faint *blue* image is strengthened by other blue rays, till the intensity of the two blue images is nearly equal. As the incident ray advances from c and d to p and p', the faint blue image becomes more intense, and the *yellow* one, receiving an accession of *blue* rays, becomes of a *bluish-white* colour. The ordinary image is *whitish* from p and p' to o, and the extraordinary a *deep blue;* but the whiteness gradually diminishes towards o, where they are both almost equally blue.

The principal axis of double refraction in *iolite* is negative. The most refracted image is *purplish-blue*, and the least refracted one *yellowish-brown*.

The following table shows the *colours* exhibited by crystals with *two* axes :—

Colours of the two Images in Crystals with two Axes.

Names of Crystals.	Axis of Prism in the Plane of Primitive Polarization.	Axis of Prism perpendicular to the Plane of Primitive Polarization.
Biaxal crystals. Mica	Blood-red	Pale greenish-yellow.
Acetate of copper	Blue	Greenish-yellow.
Muriate of copper[1]	Greenish-white	Blue.
Olivine	Bluish-green	Greenish-yellow.
Sphene	Yellow	Bluish.
Nitrate of copper	Bluish-white	Blue.
Cromate of lead	Orange	Blood-red.
Staurotide	Brownish-red	Yellowish-white.
Chloride of gold and sodium	Lemon-yellow	Deep orange.
Chloride of gold and ammonia	Lemon-yellow	Deep orange.
Chloride of gold and potassium	Lemon-yellow	Deep orange.
Augite	Blood-red	Bright green.
Anhydrite	Bright pink	Pale yellow.
Axinite	Reddish-white	Yellowish-white.
Diallage	Brownish-white	White.
Sulphur	Yellow	Deeper-yellow.
Sulph. of strontites	Blue	Bluish-white.
„ cobalt	Pink	Brick-red.
Olivine	Brown	Brownish-white.
Murexide[2]	Red	Yellowish.
Naline	Yellow	Pink.

In the last eight crystals of the preceding table the tints are not given in relation to any fixed line.

In *Withamite*, a crystal whose principal axis is negative in relation to the axis of the prism, the dichroism is beautiful, and is exhibited both in common and polarized light. When common light is transmitted through the two parallel faces of the prism, the tint is of a crimson or amethyst colour, with a mixture of straw colour. Upon turning the crystal round, the yellow tint disappears, and the colour becomes a deep crimson-red. On continuing to turn the prism, the colour changes to a straw-yellow, and at the end of half a revolution the crystal resumes its compound tint. In the groups of crystals which have penetrated the quartz, some of them occupy accidentally the position which gives the yellow colour, others that which gives the red colour, and some that which gives the compound tint, so that, without a knowledge of their dichroitic property, the group might have been considered as composed of three different sets of crystals.[3] Polarization.

The following table contains the characters of the two pencils in crystals the number of whose axes has not yet been determined.

Phosphate of iron	Fine blue	Bluish-white.
Actynolite	Green	Greenish-white.
Precious opal	Yellow	Lighter yellow.
Serpentine	Dark green	Lighter green.
Asbestos	Greenish	Yellowish.
Blue carb. of copper	Violet-blue	Greenish-blue.
Orpiment	Sulphur-yellow	Lighter yellow.

Sir David Brewster found that the dichroism of several crystals is changed by heat, and that in some cases this property may be communicated to them.[4] In several coloured glasses, too, he found an analogous property, when they had received the doubly-refracting structure either temporarily or permanently.[5]

The curious subject of dichroism has been investigated with great success by MM. Babinet, Haidinger, and Senarmont. M. Babinet found, that all *negative* crystals, such as *calcareous spar*, *corundum*, including *ruby* and *sapphire*, *tourmaline* and *emerald*, absorb in a greater degree the ordinary ray, with the exception of *beryl*, *apatite*, and some *apophyllites;* while positive crystals, such as *zircon*, *smoky quartz*, *sulphate of lime*, and common apophyllite, absorb in a greater degree the extraordinary ray. M. Babinet found also that certain crystals, such as *red tourmaline* and *ruby*, transmit rays of their peculiar colour without being polarized, in which cases the black cross of their system of rings is coloured, and this unpolarized light exists both in the ordinary and extraordinary ray.

In several minerals *three* colours have been observed, and the name *trichroitic* given them,—a name which has been abandoned for *polychroitic*, used by M. Senarmont, and *pleochroitic*, adopted by M. Haidinger of Vienna, who has treated the subject with great fulness and ability. We regret that our limits will not permit us to give any account of his researches; but the reader will find them in Poggendorf's *Annalen*,[6] and in the Abbé Moigno's *Repertoire d'Optique Moderne*.[7]

Artificial polychroism. We have already seen, in the *History* of Optics, that M. Senarmont has succeeded in imparting an artificial polychroism to crystallized substances. When certain crystals are formed in a solution containing a colouring matter sufficiently subtile, it is distributed almost molecularly in their interior between the minute laminæ of which it is composed. In this state it is absolutely foreign to the substance of the crystals, being chemically inert; and though it may spontaneously disappear after several successive dissolutions of the crystallization in pure water, yet it nevertheless communicates in the highest degree the properties of polychroism, and an energy of absorption comparable, if not superior, to those of substances naturally coloured, when it is shown in the distinctest manner.

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[1] The colours are given in relation to the short diagonal of its rhomboidal bar.

[2] When the axis of the prism is in the plane of polarization. Especially in Brazilian topaz. (See *Treatise on Optics*, edit. 1853, p. 358.)

[3] *Edin. Jour. of Science*, April 1825, vol. ii., p. 219.

[4] See *Phil. Trans.* 1819, p. 11; or *Edin. Phil. Jour.*, vol. ii., p. 346.

[5] Tom. lxi., pp. 295, 307; lxx., pp. 531; 574; lxxi., p. 321; and lxxvi., pp. 99, 294.

[6] Tom. iv., pp. 1565-1592.

Polarization.

In crystals of *nitrate of strontian*, for example, coloured with a concentrated tincture of Campeachy wood brought to a purple tint by a few drops of ammonia, the crystals resembled chrome colour in their tint, and exhibited the following phenomena of polychroism:—

1. Common white light developed by transmission at certain incidences a *red* colour, and under others, a *blue* and *violet* colour.

2. One of the doubly-refracted pencils was *red*, and the other *deep* violet, according to the thickness; and these pencils changed their colours in proportion as the crystallized plate turned in its proper plane.

3. Two similar transparent plates, superposed similarly, allow a portion of white light to pass in the purple pencil, and when superposed transversely, they stop it like tourmaline, or, at least, reduce to a violet shade so obscure, that it may be regarded as extinct.

4. If we look along the optical axes of a detached plate, perfectly pure and homogeneous, we shall see alternately, in the direction of each axis, a brilliant orange spot crossed by a hyperbolic branch. These spots spread themselves to the right and left of the principal section in the form of curved pencils, half *violet* and *deep blue*, and divide the field of the plate into two regions, when the purple tints shade off on each side of their common limit. The dark brushes interrupted by the luminous spot are fringed towards the point with a little *yellow* and *blue*, arising from the dispersion of the optical axes.

We look forward with much interest to the publication of M. Senarmont's laborious researches on this curious subject.[1]

Sect. XVII.—On the Action of the Surfaces of Crystallized Bodies upon Common and Polarized Light.

Action of crystallized bodies on light.

It was remarked by Malus, that the action of the surface of Iceland spar upon light is independent of the position of its principal section, and that its surface acts like that of any common transparent body.[2] In examining, however, the superficial action of this mineral, Sir David Brewster discovered that all its surfaces, without exception, exercise a remarkable action upon light, and that its polarizing angle varied in different azimuths, excepting when the surface was perpendicular to the axis.

If A and A″ are the minimum and maximum polarizing angles,—viz., in azimuth 0°, or in the plane of the principal section, and in azimuth 90°, or perpendicular to that plane,—he found that the variation of the polarizing angle was represented by the following expression, where A′ is the polarizing angle required at the azimuth a:—

$$A' = A + \sin^2 a\,(A'' - A);$$

in a plane perpendicular to the axis, $A'' - A = 0$, and consequently no change takes place in the polarizing angle; in planes inclined 45° 23′ to the axis on the actual faces of the rhomboid,

$$A - A = 2°\ 18';$$

and in planes coincident with the axis, $A'' - A = 4°$ nearly.

The following were the measures which were obtained on the natural faces of the rhomb:—

		Polarizing Angle.
Azimuth	0° 0′	57° 74′
„	50 57	58 32
„	90 0	59 32

On faces nearly parallel to the axes:—

Azimuth	0° 0′	54° 18′
„	90 0	58 14

Sir David Brewster also observed that the polarization was more complete in azimuth 0° than in azimuth 90° on the faces of the rhomb; but more complete in azimuth 90° than in azimuth 0° in faces parallel to the axis. Polarization.

As these experiments clearly proved that the forces which produced double refraction extended beyond the surface of Iceland spar, our author became desirous of ascertaining if the light polarized by reflection from the spar suffered any change from the same cause. He therefore thought of weakening the force which produces reflection, in order to allow the interior force to show its weaker influence; and he accomplished this by placing oil of cassia on its surface, and examining the light reflected at the separating surface of the spar and the oil. The experiments which were thus made, and which are detailed in the *Philosophical Transactions* for 1819, completely proved that the interior force polarized common light out of the plane of reflection, and modified the law of intensity, according to which light is reflected at different angles of incidence.

These experiments excited no attention till 1835, when Professor Maccullagh of Trinity College, Dublin, began to investigate the laws which regulate the reflection and refraction of light at the separating surface of two media. He had anticipated from theory effects the reverse of those deduced from the preceding experiments: and in order to account for the latter, he was obliged to modify his theoretical views, and was thus led to the result, that when a ray is polarized by reflection from a doubly-refracting surface, the plane of polarization deviates from the plane of incidence, except when the axis lies in the latter plane. The formula which expresses this deviation represents very accurately the measures of the polarizing angles in different azimuths in the natural faces of the rhomb, the only surface in which the exception is true; but at all other inclinations of the reflecting planes to the axis, the theory and the formula are in fault, for there is a large deviation when the axis or principal section of the crystal is in the plane of reflection.

Professor Maccullagh's success in deducing theoretically the general fact of a deviation increasing as the refractive power of the medium approached to that of the spar, induced Sir David Brewster to resume his inquiries, the general result of which he communicated to the British Association at Bristol in 1836, in the following very brief abstract:—

"When light is reflected at the separating surface of two media, the lowermost of which is a doubly-refracting one, the reflected ray is exposed to the action of two forces, one of which is the ordinary reflecting force, and the other a force which emanates from the interior of the doubly-refracting crystal. When the first medium is air, or even water, the first of these forces overpowers the second; and, in general, the effects of the one are so masked by the effects of the other that I was obliged to use oil of cassia, a fluid of high refractive power, in order that the interior force of the calcareous spar which I wished to examine might exhibit its effects independently of those which arise from ordinary reflection. The separating surface, therefore, which I used had a small refractive power; and the reflecting pencil is so attenuated, especially in using polarized light, that it is almost impossible to use any other light than that of the sun.

"When a pencil of common light is reflected from the separating surface of oil of cassia and calcareous spar, the general action of the spar is to polarize a part of the ray in a plane perpendicular to that of reflection, and thus to produce *by reflection the very same effect that other surfaces do by refraction.*

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[1] See *Comptes Rendus*, 1854, vol. xxxviii., pp. 101–105.

[2] *Théorie de la Double Refraction*, pp. 240, 241; and Biot's *Traité de Physique*, tom. iv., p. 339.

Polarization.

"On the face of calcareous spar perpendicular to the axis of the crystal, the effect is exactly the same in all azimuths; but in every other face the effect varies in different azimuths, and depends upon the inclination of the face to the axis of double refraction. On the natural face of the rhomb common light is polarized *in the plane* of reflection, in 0° of azimuth, or in the plane of the principal section; but at 38° of azimuth, the whole pencil is polarized at right angles to the plane of reflection; and in other azimuths the effect is nearly the same as I have stated in my printed paper.

"In order, however, to observe the change which is actually produced upon light, it is necessary to use two pencils, one polarized $+45°$, and the other $-45°$, to the plane of incidence. The planes of polarization of these pencils are inclined 90° to each other, and the invariable effect of the *new* force is to augment that angle in the same manner as is done by a refracting surface, while the tendency of the ordinary reflective force is to diminish the same angle. Hence I was led to make an experiment in which these opposite forces might compensate one another. I mixed oil of olives and oil of cassia till I obtained a compound of such a refractive power that its action in bringing together the planes of polarization should be equal to the action of the new force in separating them. Upon reflecting the compound pencil from this surface, I was delighted to find that the inclination of the planes was still 90°, and I thus obtained the extraordinary result of a reflecting surface which possessed no action whatever upon common or upon polarized light."

Sect. XVIII.—On the Double Reflection and Polarization of Light by the Surfaces of certain Minerals.

Double reflection.

As the light which transparent bodies reflect from their first surface does not enter the substance of the body, it was always supposed to be colourless, whatever was the colour of the body which reflected it. This supposition was not confirmed by experiment till chemistry presented us with various substances in which the light which they reflected appeared to be distinctly coloured. Having observed this fact, Sir David Brewster in 1845 examined the action of this class of crystals upon light, particularly *chrysammate of potash, chrysammate of magnesia, murexide*, and various other crystals in which the coloured reflection took place. The *chrysammate of potash*, which crystallizes in very small, flat, rhombic plates, has the metallic lustre of gold, from which it derives its name of *golden sand*. When the sun's light is transmitted through the rhombic plates, it has a *reddish-yellow* colour, and is wholly polarized in one plane. When the crystals are pressed with the blade of a knife on a piece of glass, they can be spread out like an amalgam. The light transmitted through the thinnest films thus produced consists of two oppositely-polarized pencils—the one of a bright *carmine-red*, and the other of a pale *yellow*. When the films are thicker, the two pencils approach to two equally bright *carmine-red* pencils.

When common light is reflected at a perpendicular incidence from the surfaces of the crystals or films, it has the colour and metallic lustre of virgin gold. It becomes less and less *yellow* as the incidence increases, till at very great incidences its colour is a *pale bluish-white*. This reflected pencil consists of two oppositely-polarized pencils—one polarized in the plane of reflection, and of a *pale bluish-white* colour at all incidences; and the other polarized perpendicularly to the plane of reflection, and of a *golden-yellow* colour at small incidences, passing successively into a *deeper yellow, greenish-yellow, green, greenish-blue, blue*, and *light pink*, as the angle of incidence increases. This very remarkable property is exhibited under the usual modification if the surface of the chrysammate is in optical contact with fluids, or if it is a surface produced by pressure and traction. The same property is seen when the crystal is in the act of being dissolved, or when a fresh surface is exposed by mechanical means. When the chrysammate is re-crystallized from an aqueous solution, it appears in tufts of prisms of a bright red colour, the golden reflection being overpowered by the transmitted light; but when these tufts are spread into a film by pressure and traction, the golden-yellow colour reappears. When the crystals of chrysammate are heated with a spirit-lamp, or above a gas-burner, they explode with a flame and smoke like gunpowder;[1] and, by continuing the heat, the residue melts, and a crop of colourless amorphous crystals is left.[2]

Polarization.

This interesting subject has been studied by M. Haidinger under the name of *chatoyement metallique*. M. Babinet had found that in all crystals, whether negative or positive, the *most refracted* ray, which in the first of these classes is the *ordinary* one, is more absorbed than the *extraordinary* or least-refracted ray; while the least-refracted ray, or the extraordinary one, is the least absorbed in the other class. Taking as the ground of comparison this law of Babinet, M. Haidinger found that the direction of the polarization of the reflected light coincided with the direction of the polarization of the ray which was most absorbed in doubly-refracting crystals.[3]

Professor Stokes observed the same property of double reflection and polarization in *carthamine*, or safflower-red, and had been led independently to the fact of the orientation of the reflected pencils.[4]

Sect. XIX.—On the Mutual Action of Polarized Rays.

Mutual action of polarized rays.

As this curious subject has been studied only by MM. Arago and Fresnel, we shall therefore make no apology for giving an account of the results which they obtained nearly in the words of M. Fresnel himself:[5]—

"In studying the interference of polarized rays, M. Arago and I found that they exercise no influence upon one another when their planes of polarization are perpendicular to each other—that is, that they cannot then produce fringes, although all the necessary conditions for their appearance in ordinary cases be scrupulously fulfilled. Three principal experiments illustrate this fact. The first, by M. Arago, consists in making two pencils, emanating from the same point, and introduced by two parallel slits, traverse two piles of very thin transparent plates, such as those of mica or blown glass, which are sufficiently inclined to each other to polarize almost completely each of the two pencils, taking care that the two planes are perpendicularly inclined to each other. In this case no fringes can be perceived, whatever care may have been taken thus to compensate the differences of both in varying very gently the inclination of one of the piles; but when the planes of incidence of the piles are no longer perpendicular to each other, they always cause the fringes to appear. In proportion as the planes cease to be parallel the fringes become weaker, and they disappear altogether when they are rectangular. It

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[1] Sir David Brewster found the same explosive property in *aloetinate of potash*.

[2] *Proceedings of Phil. Soc. St Andrews*, Jan. 5, Feb. 2, &c., 1846; *Report of Brit. Assoc.* 1846, p. 7; and Abbé Moigno's *Repertoire*, &c., vol. iv., p. 1558; see also *Phil. Mag.*, March 1854, vol. vii., p. 171.

[3] See Poggendorf's *Annalen*, tom. lxx., lxxi., lxxvi.; and Moigno's *Repertoire d'Optique*, iv. 1564.

[4] *Phil. Mag.*, December 1853.

[5] Pouillet, *Elemens de Physique Experimental et de Meteorologie*, liv. viii., chap. iii.

Polarization. results from these experiments, that rays polarized in the same plane influence one another, like the rays of light not modified; but this influence diminishes in proportion as the planes of polarization deviate from one another, and becomes nothing when they are rectangular.

"The following experiment leads to the same results:—Take a plate of sulphate of lime or of rock-crystal parallel to its axis, and of a uniform thickness; cut it in two, and place each of the halves upon one of the slits of the screen. I suppose that we have turned the two halves in such a way that the edges which were in contact before the division of the plate are parallel, and the axes will also be parallel. But in this case we only perceive a single group of fringes in the middle of the bright space as it was before the division of the plates. But if we turn one of these halves in its plane, thus disturbing the parallelism of their axes, we make two other groups of fainter fringes spring up, situated one on the right and the other on the left of the group in the middle, and which are completely separated from it, in the white light when the plates of rock-crystal or of sulphate of lime which are used are only a millimetre thick. It is to be remarked that the number and breadth of the fringes lying between the middle of one of these groups and the central group is proportional to the thickness of the plates for crystals of the same kind, or whose double refraction is of the same strength, like rock-crystal and sulphate of lime. In proportion as the angle of the two axes increases, these new groups of fringes become more and more distinct, and attain at last their maximum intensity when the axes of the two plates are perpendicular to each other. In this position, the central group, which had been gradually weakened, has altogether disappeared, and is replaced by a uniform light. Hence the rays which produce them, by interference, are no longer capable of influencing one another.

"From the position of these fringes, it is easy to see that they result from the interference of the rays which have undergone the same kind of refraction in the two plates. Hence the fringes of the central groups were formed by the superposition of those which arise—1. From the interference of the *ordinary* rays of the *left* plate with the *ordinary* rays of the *right* plate; 2. From the interference of the *extraordinary* rays of the *first* plate with the *extraordinary* rays of the *second*. The two eccentric groups, on the contrary, arise from the interference of the rays which have undergone different refractions in the two plates; and as it is the *ordinary* rays which move with the greatest velocity in *sulphate of lime* or *rock-crystal*, we see that if we employ one of these two species of crystals, the *left* group ought to be formed by the union of the *extraordinary* rays of the *left* plate with the *ordinary* rays of the *right* plate, and the *right* group by the union of the *extraordinary* rays of the *right* plate with the *ordinary* rays of the *left* plate. This being established, it remains now to determine the direction of polarization in each of the pencils which interfere, in order that we may deduce from it what are the relative directions of the planes of polarization which favour or hinder their mutual influence. When the plates are one or two millimetres thick, and one of their edges is cut obliquely to separate the ordinary and extraordinary rays, we find that they are effectually polarized, the first in the principal section, and the others in a perpendicular direction. When the axes of the two plates were parallel, the rays which had experienced the same refractions in the two crystals were found polarized in the same direction, and those of contrary colours in rectangular directions. It is thus that the group of fringes in the middle which proceed from the interference of rays of the same name had a maximum intensity, and the two others, which resulted from the interference of the rays of contrary names, did not appear again. But when the axes of the two plates formed an oblique angle, of 45° for instance, the rays of a contrary name, and those of the same name, could act at the same time one upon the other, since their polarizing planes were no longer rectangular, and the three groups of fringes were produced. When, in short, the axes became perpendicular to one another, the rays of the same colour were polarized in rectangular directions, and the central group, to which it had given birth, vanished, while the *ordinary* rays of the *left* plate were then polarized *parallel* to the *extraordinary* rays of the *right* plate; and this is the cause why the right group which they produce attained its maximum intensity. It is the same with the *left* group, arising from the interference of the *ordinary* rays of the *right* plate with the *extraordinary* rays of the *left* plate. Polarization.

"The following is a *third* experiment, which confirms the results of the first:—Having polished a rhomb of calcareous spar upon two opposite faces, I sawed it perpendicularly to these faces, and obtained two rhombs of equal thickness, in which the routes of the ordinary and extraordinary rays were exactly parallel at the same incidence. I placed them one before the other, so that the rays from the luminous point which had traversed the first rhomb passed perpendicularly through the second; the principal section of the second rhomb being perpendicular to that of the first, so that the four pencils were reduced to two. The ordinary pencil of the first rhomb was refracted extraordinarily in the second, and the extraordinary pencil of the first was refracted ordinarily in the second. From this arrangement it followed, that the difference of the route, proceeding from the difference of velocity of the ordinary and extraordinary rays, was found compensated for by the two emerging pencils. They crossed each other, too, at a very small angle, and though the fringes ought to have had a magnitude sufficient to be seen, yet I never could succeed in making them appear.

"While I was searching for them with a magnifying glass, I gently varied the direction of one of the rhombs, in order to compensate the effect resulting from any difference of thickness, but I never could perceive any fringes. I easily succeeded, however, in making them appear by employing the light which had been polarized before it entered the rhombs, and in causing it to receive a new polarization after its emergence. It is then demonstrable *that rays polarized at right angles cannot exert any sensible influence upon one another*.

"Another remarkable fact is, that when they have been once polarized in rectangular directions, it is not sufficient that they are brought back to a common plane of polarization, in order that they may give apparent signs of their mutual influence. If we cause the rays which have emerged from the two slits, and which are polarized at right angles, to pass through a pile of inclined plates of plane glass, no fringes are perceived, in whatever direction its rays of incidence are turned. Instead of a pile, we may employ a rhomb of calcareous spar. If we incline its principal section at 45° to the plane of polarization of the incident pencils, so that it divides into two equal parts the angle which they make with each other, each image will contain the half of each pencil, and these two halves having the same plane of polarization in the same image, ought to produce fringes there, if it is sufficient to bring back the rays to a plane of common polarization, to re-establish the apparent effects of their mutual influence. But the fringes can never be obtained by this method as long as the rays have not been polarized in the same plane, before they were divided into two pencils polarized at right angles.

"When the light has experienced this previous polarization, on the contrary, the interposition of the rhomb makes the fringes reappear. The most advantageous direction to give the primitive plane of polarization is that which divides into two equal parts the angle of the rectangular planes in which the two pencils are polarized in the second

Polarization.

instance, because then the incident light is equally divided between them. Suppose that the primitive plane of polarization is horizontal, it will be necessary that the planes of polarization impressed upon each of the two pencils be inclined 45° to the horizontal plane, the one above it and the other below it, in such a manner that they remain perpendicular. We can obtain this rectangular polarization either with the help of two little piles, or with two plates whose axes are rectangular axes, or with a single crystallized plate. We shall only consider this last case.

"To divide the light into two pencils, which cross under a small angle, and which may thus produce fringes, the apparatus of two glass mirrors blackened behind is generally better than the screen pierced by two slits, because it produces more brilliant fringes. It has, besides, the advantage of giving immediately to the two pencils the previous polarization necessary to our experiment; it is sufficient for this purpose that the mirrors be inclined 35° to the incident rays. We place near them, in the line of the reflected rays, and perpendicularly to their direction, a plate of sulphate of lime or of rock-crystal parallel to the axis, and one or two millimetres thick, inclining its principal section 45° to the plane of primitive polarization, which we have supposed horizontal. The apparatus being thus placed, we only see a single group of fringes across the plate as before its interposition, and it occupies the same place. But if we put before the magnifying glass a pile of glass plates inclined in a horizontal or vertical direction, we discover on each side of the central group another group of fringes, which is the more distant as the crystallized plate is thicker. If we replace the pile of plates by a rhomb of calcareous spar, whose principal section is divided horizontally or vertically, we shall see in each of the two images the two systems of additional fringes which the interposition of the pile of plates has caused to appear, and these two images are complementary to one another.

"In this experiment the rays which have experienced the refractions of opposite names cannot influence each other, because, in emerging from the same plate in the case we are now considering, they are found polarized in rectangular directions; consequently the groups to the right and the left cannot exist, at least while we have not re-established the mutual influence of those rays by bringing them to a common plane of polarization; this is what is effected by the interposition of the pile of plates or of the rhomb. The fringes thus produced are the more distinct, as the two pencils of contrary names which concur in their formation are more equal in intensity; and this is the reason why the direction of the principal section of the rhomb, which makes an angle of 45° with the axis of the plate, is the most favourable to the appearance of the fringes. When the principal section of the rhomb is parallel or perpendicular to that of the plate, the rays refracted ordinarily by the plate pass entirely into one image, instead of being divided between the two, and all the extraordinary rays pass into the other image, so that there can be no more interference between them; and the additional groups of fringes disappear, each image presenting only the fringes which resulted from the interference of the rays of the same name,—that is to say, those which compose the central group."

Sect. XX.—On the Production of Double Refraction and Polarization by Heat, Cold, Pressure, Slow and Rapid Induration, Traction, Electro-Magnetism, and Laminated Structure.[1]

Production of double refraction.

The various phenomena of double refraction, and the system of polarized rings, may be produced either transiently or permanently in glass and other substances by heat and cold, compression and dilatation, and by slow and gradual induration. The phenomena thus produced in polarized light are exceedingly beautiful, and throw much light on the subject of double refraction.

Polarization.

Art. I.—On the Transient Influence of Heat and Cold.

The influence of heat and cold may be exhibited in *cylinders*, *tubes*, *spheres*, *cubes*, and *rectangular plates* of *glass*, all the phenomena of which were discovered by Sir David Brewster.

1. *Cylinders of Glass with One Axis of Double Refraction.*

1. *Negative Axis.*—If we take a cylinder of glass ABCD (fig. 228), from half an inch to an inch in diameter, or upwards, about half an inch or more in thickness, and transmit heat uniformly from its circumference to its centre, it will exhibit, when placed between the polarizing and the analysing plate, and held about 8 or 10 inches from the eye, the system of uniaxal rings shown in fig. 228, exactly similar to those in fig. 179; and by turning round the analysing plate we shall see the complementary set, as in fig. 181. These rings will be seen as if they were in the substance of the glass; and hence, if we cover up any part of the circular surface, we shall cover up a corresponding part of the system of rings. The axis of the system, or of double refraction, is here fixed in the axis of the cylinder, and does not lie in every direction parallel to that axis, as in regularly-crystallized bodies.

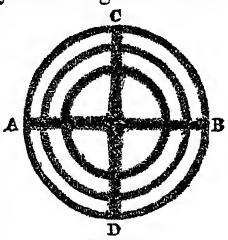

Fig. 228.

The system of rings thus produced is *negative*, like those in *calcareous spar*.

As soon as the heat reaches the axis of the cylinder, the rings become less bright, and they disappear entirely when the heat is uniformly distributed through the glass.

2. *Positive Axis.*—If we heat a similar cylinder of glass uniformly in boiling oil or otherwise, and cool it rapidly at its edges by encircling its margin with a cold and good conducting material, it will exhibit a similar system, which will vanish when the glass is uniformly cold. This system of rings, however, is *positive*, like those of zircon; and if it is placed above the equal *negative* system, produced as already described, they will destroy each other. If the two systems are not equal, we shall have a system equal to their difference, as in positive and negative uniaxal crystals. In both these systems the tint at any point varies as the square of the distance of that point from the axis; so that if T is the tint at any distance D, the tint t corresponding to any distance d, will be $t=\frac{TD^2}{d^2}$. If V is the velocity of the ordinary ray, we shall have the velocity of the extraordinary ray $v=V^2+ad^2$.

If we transmit polarized light through the cylindrical surface of these cylinders, we shall observe the phenomena of biaxal systems exactly the same as in rectangular plates (fig. 240), the tints being produced by the action of the positive or negative axis of the cylinder acting in opposition to an axis passing through each diameter of the cylinder, drawn perpendicular to any point in the middle line of the cylindrical surface.

2. *Oval Cylinders, with Two Axes of Double Refraction.*

If we perform the two experiments above described with

[1] See *Phil. Trans.* 1816, pp. 46–114, 156–178; *Edin. Trans.* 1816, vol. viii., pp. 353–371.

Polarization.

oval cylinders, as in fig. 229, we shall have a system of rings with two axes. A new axis is developed perpendicular to the axis of the cylinder; and in the case of the heated cylinder, the new axis at O is a positive one, while in the cooled cylinder it is a negative one, the neutral black lines AD, CB separating the two classes of tints, and corresponding to the dark hyperbolic branches in biaxal systems of rings. The figure referred to is that shown in azimuths inclined 45° to the plane of primitive polarization; but in the azimuths of 0° and 90°, the branches AD, CB resume the form of the rectangular cross.

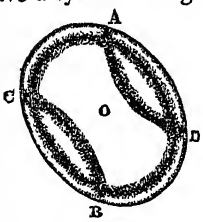

Fig. 229.

3. *Cubes and Parallelopipeds of Glass with Double Refraction.*

Cubes of Glass.—When the shape of the glass is that of a cube, as in fig. 230, the figure which it produces in amizuth 0° by the two processes of heating and cooling is that shown in the figure, the tints being negative or positive, according as we apply heat or cold. The complementary system is shown in fig. 231.

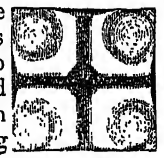
Fig. 230.

Fig. 231.

Parallelopipeds of Glass.—In a parallelopiped 0·38 of an inch square, and 1·11 long, the *direct* and *complementary* systems at 0° of azimuth are shown in figs. 232 and 233. The first of these consist of a black cross surrounded with beautiful fringes of contrary flexure, and four bright green spots of the third order. The coloured spots at the angles of fig. 233 are of a brilliant pink colour, with a spot of blue in the middle of each. When the azimuth is 45°, the direct and complementary systems change into figs. 234 and 235.

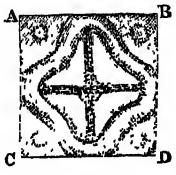

Fig. 232.

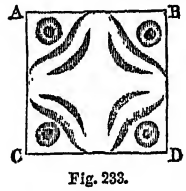

Fig. 233.

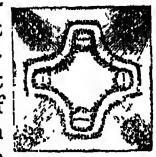
Fig. 234.

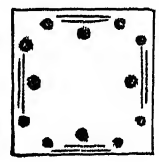
Fig. 235.

4. *Cylindrical Tubes of Glass with Two Axes of Double Refraction.*

When the cylinder has the form of a tube, as in fig. 236, the double refraction is singularly distributed by the application of heat or cold either to the outside ACBD of the cylinder, or to its inside *acbd*, or to both. A black circular fringe *mpno* is the central line which separates the outside or positive structure from the internal negative structure, and *vice versa*. The breadth of the internal annulus *ao* is always less than A*o*, that of the external one. They approach to equality as the bore of the cylinder widens, and the negative structure grows very small, as shown in fig. 237, when the bore diminishes; so that when the bore becomes infinitely small, the system becomes either wholly negative or positive, according as heat or cold has been used. If when fig. 236 is fully developed, we cut a notch EF in the cylinder, we shall have a biaxal system of fringes, in which there is a positive structure between two negative ones, or *vice versa*, as shown in fig. 238.

Fig. 236.

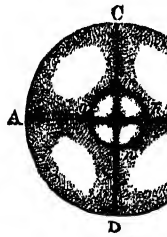

Fig. 237.

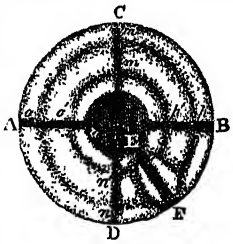

Fig. 238.

The diameter *op* (figs. 236 and 237) is a geometrical mean between the interior and exterior diameters of the tube,—that is, $op = \sqrt{(AB \times ab)}$.

5. *Rectangular Plates of Glass with Planes of Double Refraction.*

If a well-annealed parallelopiped of glass EFDC (fig. 239) is submitted to the processes already described, or even if we lay one edge of it CD on a piece of iron almost red hot, and place the whole between the polarizing and analysing plates, so that if the heated edge CD is inclined 45° to the planes of primitive polarization, and the eye can see the whole surface of the glass, a series of remarkable phenomena will be produced. The moment the heat enters the lower surface at CD fringes of brilliant colours are seen above CD, and almost at the same instant, before the heat has reached the upper surface EF, or even the central line *ab*, *similar* fringes will appear at EF. Colours, at first faint blue, then white, yellow, orange, red, &c., of the first order spring up at *ab*, and these central colours are separated from those at the edges by two dark lines or planes MN, OP, corresponding to the hyperbolic branches in biaxal crystals, the double refraction between MN and OP being *negative* in reference to a line perpendicular to the fringes, while it is *positive* without MN and OP. The tints thus developed are those of Newton's scale.

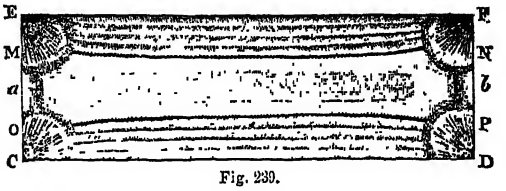

Fig. 239.

If T is the central tint in the line *ab*, D the distance of either of the lines MN, OP from *ab*, the tint *t* at any other distance *d* will be, $t = T - \frac{T d^2}{D^2}$, a formula deduced from the combination of two axes. The term $\frac{T d^2}{D^2}$ represents the influence of the principal axis or axes perpendicular to the line *ab* at every point of it; but as the axis in the plane of the plate produces a uniform tint T whose maximum is in the line *ab*, where the action of the other axis disappears, and as these axes oppose each other by acting rectangularly, they will compensate each other in the lines MN, OP, and the tint at any point must always be equal to the difference of the tints, or to $T - \frac{T d^2}{D^2}$.

The magnitude 2D, or the distance between MN and OP, is a function of the breadth of the plate B, and 2D : B = 10 : 16·02, and D = ·312 B². (*Edin. Trans.* viii. 355.)

Polarization.

The fringes seen through the thickness of the plates is shown in fig. 240, and the one seen through the ends in fig. 241.

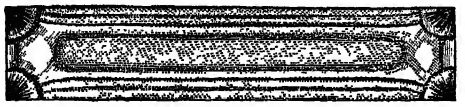

Fig. 240.

If we wish to find the tints in reference to the lines MN, OP, let δ, δ' be the distances from these lines of any point whose distance from ab is d, then we have $\delta = 1-d$, $\delta' = 1-d$, and $\delta\delta' = 1-d^2$; that is, the tint at any point varies as the product of the distances of that point from the planes of the resultant axes MN, OP. If we make $v^2 = V^2 + a\delta\delta'$, an expression which gives v the velocity of the extraordinary ray, we shall have the extraordinary refraction in such plates.

Fig. 241.

6. *Spheres and Spheroids of Glass with Double Refraction.*

Spheres.—If we place a sphere of glass in a glass trough of hot oil, or otherwise heat it regularly, we shall find that when the heat is passing to the centre of the sphere, it will exhibit a positive uniaxal system of rings like that in fig. 228, in every direction in which we transmit the polarized light; that is, it will have an infinite number of *positive* axes of double refraction.

If a hot *sphere* of glass is immersed in a glass trough of cold oil, a similar system of rings will be produced in every possible direction; but it will be *negative*.

Spheroids.—If we substitute *oblate* and *prolate* spheroids in place of the sphere in these experiments, we shall find that they will have each a *positive* system of rings round their axis of revolution. If the polarized light is transmitted through an equatorial diameter, we shall find that there are two axes of double refraction, the black cross opening out when the axis of revolution is inclined 45° to the plane of primitive polarization.

In the prolate spheroid the black cross opens out in a different plane.

7. *On the Effects produced by Combining Plates of Glass under the transient influence of Heat and Cold.*

If we combine any two plates of the same shape, the resulting system of fringes will be equal to the sum of their systems or effects, if the plates are of the same name,—that is, both *positive* or both *negative*,—or to the difference of their effects, if they are of different names. When the plates are solids or symmetrical forms, such as cylinders, cubes, or quadrangular plates, no essential variation of figure is produced by the combination; but when the plates are rectangular, very interesting phenomena are exhibited when plates of the same or of different names are crossed rectangularly. Sir David Brewster has given formulæ for calculating the forms of the compound or isochromatic curves, as he calls them, but our space will only permit us to exhibit the effects to the eye.

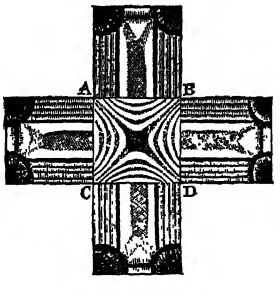

Fig. 242.

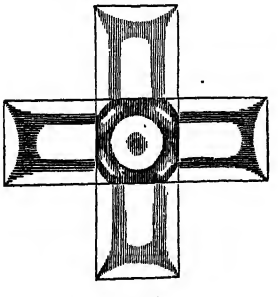

Fig. 243.

Polarization.

When equal rectangular plates of *similar names*,—that is, both negative or both positive,—are crossed, the phenomena of the *intersectional fringes*, as they may be called, are shown in fig. 242, where the isochromatic curves are *hyperbolas*.

When the plates are of *different names*, the one *positive* and the other *negative*, and of the same breadth, and the same number of fringes, the isochromatic curves are *circles*, as in fig. 243.

When the plates are of *different names*, and of different breadths, but containing the same number of fringes, the isochromatic curves will be *ellipses*, as in fig. 244.

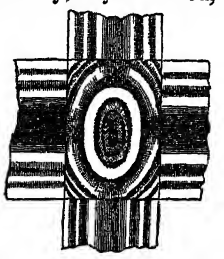

Fig. 244.

8. *On the Effects produced by Altering the Form of, or Subdividing Plates of Glass under the influence of Heat or Cold.*

If we alter the shape of any of the plates above described, the form of the isochromatic curve is immediately changed. If we cut any rectangular plate into two by a line passing through its middle, each of the two plates thus produced has the property of the whole plate, though the fringes are less numerous. If a plate ABCD gives the tints shown in fig. 245, OP and MN being the dark neutral lines; then if we cut it with a diamond at ab, so as to subdivide it into two plates, as in fig. 246, each of the plates EFrs, GHrs will have the same structure as ABCD,—viz., two neutral lines op, mn, and assume positive and negative tints.

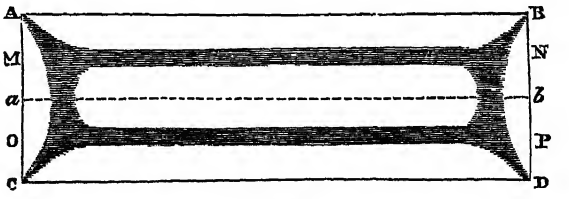

Fig. 245.

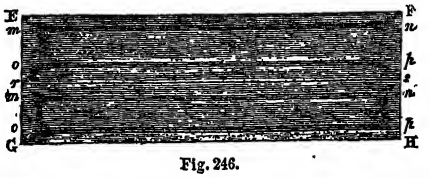

Fig. 246.

Art. II.—On the Permanent Influence of Rapid Cooling.

In March 1814 Sir David Brewster found that glass melted and suddenly cooled, as in the case of Prince Rupert's drops, possessed a permanently doubly-refracting power, and he communicated this fact in a letter to Sir Joseph Banks, dated April 8, 1814 (*Phil. Trans.* 1814), and without knowing that Dr Seebeck had published in December 1814 similar results with cubes of glass, our author had discovered that cubes, cylinders, plates, spheres, and spheroids of glass, exhibiting permanently the phenomena described in the preceding pages, may be formed by bringing them to a red heat, and cooling them rapidly and equally on their edges. A great variety of beautiful optical figures, developed in polarized light, may thus be obtained by cooling the glass on metallic patterns. A very simple effect of

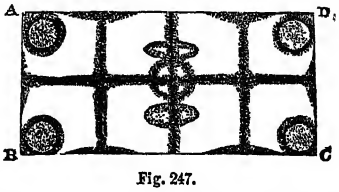

Fig. 247.

Polarization. this is shown in fig. 247, where the plate of glass was cooled by resting it at its centre on a cylinder of iron.

Art. III.—On the Production of Double Refraction by Compression and Dilatation.

The effects of compression and dilatation in producing double refraction were discovered by Sir David Brewster, and communicated to the Royal Society in 1815. Our limits will permit us only to give a slight notice of them.

The phenomena both of compression and dilatation or extension may be well seen by bending, merely with the force of the hands, a square rod, or a long and narrow plate of glass, as in fig. 248. When it is held between the po-

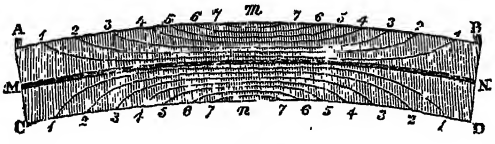

Fig. 248.

larizing and analysing plate, eight or ten inches from the latter, with its edge AB inclined 45° to the plane of primitive polarization, the whole thickness of the glass will be covered with two series of coloured fringes, like those in the figure separated by a dark neutral line MN, where there is neither compression nor dilatation. The fringes on the convex side are *negative*, being produced by the *extension* of the glass in the direction *m*A, *m*B, while those on the concave side are produced by the *compression* of the glass in the directions C*n*, D*n*. The isochromatic curves marked by similar figures, indicating the orders of the colours, are bent as in the figure.

When a plate of bent glass producing fringes crosses another at right angles, the effect at the intersectional space is shown in fig. 249, where the tint is supposed only to be the white of the first order.

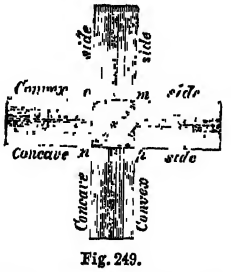

Fig. 249.

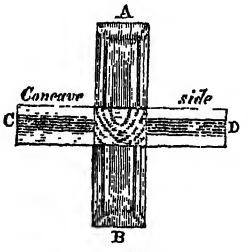

Fig. 250.

When a plate of bent glass is crossed with a plate crystallized by heat, the fringes in the intersectional square will be *parabolas*, as shown in fig. 250, whose vertex will be towards the *convex* side of the bent plate, if the principal axis of the other plate is *positive*, but towards the *concave* side, if that axis is *negative*.

Art. IV.—On the Double Refraction Produced by the gradual Induration and Difference of Density in Soft Solids.

The phenomena of luminous sectors, separated by a black cross at the central part of the uniaxal system of rings, which Sir David Brewster discovered round cavities in the diamond, in glass, and in various gums, arise from the gradual induration of the mass, combined with the elastic pressure of the air included in the cavities. They are therefore not properly cases of induration alone.

When isinglass is dried in a circular trough, it exhibits, by polarized light, the uniaxal system of rings like glass in fig. 228.

When it is indurated in the form of a rectangular mass, by the exposure of two sides, fringes are produced parallel to these sides, and biaxal like those in rectangular plates of heated glass. Polarization.

A sphere of transparent jelly or isinglass, when allowed to indurate gradually, will have an axis of double refraction in every direction, like a sphere of glass heated. In like manner an indurated spheroid will exhibit the biaxal structure of a spheroid of glass.

The most splendid examples, however, of this class of facts are exhibited in the lenses of fishes and animals, as shown in figs. 251 and 252. The first of these shows the

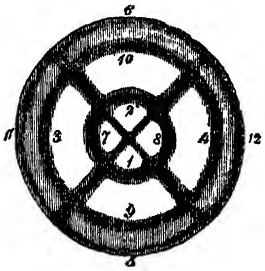

Fig. 251.

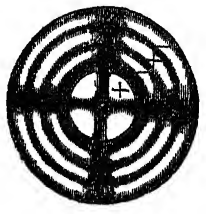

Fig. 252.

doubly-refracting structure of the crystalline lens of a cod, along the axis of vision. The central and the external luminous sectors have a *negative* doubly-refracting structure, while the intermediate ones have a *positive* structure.[1]

The figure given by the crystalline lens of a cow is shown in fig. 252, where there are *four* series of luminous sectors, the central ones being *positive* (marked +), the next *negative* (marked −), the next *positive*, and the last *negative*.[2]

Art. V.—On the Production of the Doubly-Refracting Structure in Crystalline Powders by Compression and Traction.

In spreading out on polished or ground glass, by compression and traction, the crystalline powders of *chrysammate of potash* and other bodies, Sir David Brewster obtained a transparent film which exhibited the phenomena of double reflection and polarization as perfectly as a large crystal. The film of *chrysammate of magnesia*, which is a red powder with specks of yellow reflected light, exhibits neutral and polarizing axes in the light which they transmit, and doubly-polarized pencils in the light which they reflect.

The same property was found in a great number of crystalline powders, and in some soft solids, such as almond, soap, tallow, bees'-wax, bees'-wax mixed with rosin, and in oil of mace. For a list of the substances in which this property is produced, and of those in which it is not, with an attempt to explain the manner in which the crystalline particles have their axes brought into parallelism, we must refer the reader to the original paper.[3] We may, however, observe, that the development of electrical poles in crystals by heat and friction, and the influence of traction in drawing prismatic crystals, and those whose length exceeds their breadth, into parallel positions, may act either separately or in combination in producing the effects we have been considering.

Art. VI.—On the Influence of Electro-Magnetism in Producing Double Refraction, &c.

In Professor Forbes's PRELIMINARY DISSERTATION on Mathematical and Physical Science, a brief notice has been given of two important discoveries,—the one by Dr Faraday, the other by Professor Plücker,—showing the influence of electro-magnetism in producing double refraction, and its action upon the optic axes of crystals.

[1] See *Phil. Trans.* 1816, p. 311. [2] Ibid. 1837, p. 253. [3] *Edin. Trans.* 1853, vol. xx., p. 555; and *Phil. Mag.* 1853.

Polarization.

An account of this great discovery, and of the researches of M. Mathiessen of Altona and others, has been given in our article MAGNETISM, chap. iii., sec. 3.

In the extensive series of experiments by M. Bertin on *Circular Magnetic Polarization*, to which we have done little more than allude in that article, he obtained many important results, of which we shall now give a brief notice. In these experiments M. Bertin employed both the electro-magnet of M. Becquerel and the apparatus of Ruhmkorff. Becquerel's improvement of Faraday's apparatus consists in making the polarized ray pass not merely near the line of the poles, but *through the line itself*, by piercing the electro-magnet in that direction, which is done by placing perforated terminations on the two poles.[1] This is proved by the following experiments:[2]—

	Millimetres.	Rotation *with* the Terminations.	Rotation *without* the Terminations.
Very thick flint-glass	55·6	21° 0′	4° 30′
Faraday's flint-glass	48·3	25 6	6 30
„ „	183·0	18 20	2 30
Distilled water	130·0	5 30	3 0
„ „	30·0	3 50	0 0

This increase in the rotation is still better obtained with Ruhmkorff's apparatus, in which the helices are pierced in the direction of their axes. By means of one of these apparatuses, 54 kilogrammes in weight, and with 80 elements of Bunsen's battery, M. Bertin was able to show the experiment at a public lecture.

M. Bertin made a number of experiments to determine the law of the thickness and of the distance both with one and with two poles. The following is the law of the distance:—

When the distances of the flint-glass from the coil increase in arithmetical progression, the rotations of the plane of polarization are in geometrical progression.

If we call A the rotation produced by the flint-glass *in contact* with the coil, and if Ar is the rotation produced at the distance of one millimetre, the action of the coil y at any distance x, in millimetres, will be $y = Ar^x$.

If each of the different sections of a substance is acted upon as if it were a single section, then we shall have the law of the thickness. If in a thickness of e millimetres we consider e sections of one millimetre, and call c the rotation produced by each of these sections, when in contact with the pole; then the rotation y, produced in contact by the thickness e, will be the sum of the terms of a geometrical progression, the first term of which is c, the course r, and the number of the terms e; that is, we shall have

$$A = c\frac{1 - r^e}{1 - r};$$

whence

$$y = c\left(\frac{1 - r^e}{1 - r}\right) r^x,$$

which represents the general action of a single pole.

By the formula $y = Ar^x$, which gives the action of a single coil, we have also that of the two electro-magnetic coils facing each other with the poles of opposite names. If these two coils are at a distance d, the flint-glass of e thickness, placed at the distance x from the first, will be distant $d - e - x$ from the second; and as the two actions add to each other, the total rotation z will be

$$z = c\left(\frac{1 - r^e}{1 - r}\right)(r^x + r^{d-e-x}).$$

The first term of the geometrical progression—namely, c—is called by M. Bertin the *coefficient of magnetic polarization*, and is calculated by comparing two rotations observed at short intervals upon two substances placed under certain circumstances, but always between two poles at the same distance. These coefficients for different substances are given in the following table:— Polarization.

	Coefficient c.
Faraday's flint-glass	1·20
Guinaud's do.	0·87
Mathiessen's do.	0·83
Common do.	0·59
Bichloride of tin	0·77
Sulphuret of carbon	0·74
Proto-chloride of phosphorus	0·51
Chloride of zinc, dissolved	0·55
Chloride of calcium, dissolved	0·45
Water	0·25
Alcohol, ordinary, of 36° Reaumur	0·18
Æther	0·15

Art. VII.—On the Influence of Electro-Magnetism on the Axes of Crystals.

In repeating the experiments of Dr Faraday on diamagnetism, M. Plücker[3] of Bonn was led to a very beautiful discovery. When a crystal with *one* optical axis, like *dioptase*, was suspended freely between the poles of an electro-magnet, the optical axis placed itself *equatorially* or perpendicular to the line joining the poles of the magnet. When a crystal with *two* optical axes, like *topaz*, was similarly suspended, the line bisecting the optical axes took the same position. These two crystals are *positive;* but when the crystals were *negative*, the same lines took the *axial* position; that is, pointed in a direction parallel to the line joining the poles of the magnet. "Hence," says M. Plücker, "in a crystal which is neither transparent nor shows any trace of its crystalline structure, we may, by means of a magnet, find its optical axis or axes, and at the same time we get a new proof of the connection between light and magnetism." These experiments were repeated and confirmed by Dr Faraday, under M. Plücker's "own personal tuition," with *tourmaline, staurolite, red ferro-prussiate of potash*, and *Iceland spar*. M. Plücker also found that certain crystals, —*uniaxal*, like *oxide of tin*, and *biaxal*, like *kyanite* or *blue disthene*,—have such a degree of magnetic polarity that they point to the north by the magnetic power of the earth.

In using crystals of bismuth, antimony, and arsenic, Dr Faraday obtained results which differed from those produced by diamagnetic or by ordinary magnetic action, and also from those obtained by Plücker. They indicated a new force, which he calls *magne-crystallic*, which in relation to the magnetic field is *axial*, and not equatorial like that of Plücker. It does not manifest itself by attraction or repulsion, but gives *position* only. *The line of force tends to place itself parallel or at a tangent to, the magnetic curve, or line of magnetic force passing through the place where the crystal is situated.*[4]

Results differing from those of Plücker were subsequently obtained by Professor Tyndall and M. Knoblauch. Out of eleven crystals of Iceland spar, *five* obeyed the law of Plücker, and *six* contradicted it. In continuing their researches, they found at the conclusion "that the attraction or repulsion of the optical axes is a secondary result, depending first of all upon the magnetism or diamagnetism of the substance; and secondly, upon the manner in which either force is modified by the peculiar structure of the crystals." "The conducting power," they add, "so to speak, of Iceland spar for both magnetism and diamagnetism appears to be in directions perpendicular to the lines of cleavage. M. Plücker has, in a subsequent paper,[5] admitted the correctness of these views, and says that some of them had been previously published by himself.

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[1] *Ann. de Chim.*, &c. 3d series, vol. xvii., p. 437.
[2] The numbers given by M. Bertin are the *total rotations* produced in the plane of polarization.
[3] See *Phil. Mag.*, June 1849, vol. xxxiv., p. 450. [4] *Phil. Trans.* 1849, p. 1, &c. [5] *Phil. Mag.*, June 1851, vol. i., p. 447.

Polarization.

Art. VIII.—On the Polarization produced by Laminated Structure, or Lamellar Polarization.

We have already seen that in certain imperfect crystals of nitre there is a laminated structure, in virtue of which the incident light is polarized as if by a pile or bundle of plates, and after passing through the crystal, the emergent light is analysed by other laminæ lying in an opposite plane, and exhibits the biaxal system of rays produced by that salt. The same polarization is produced by films of mica and decomposed glass; and this is true *lamellar polarization.*

M. Biot has given the same name to a supposed structure which produces numerous remarkable phenomena of polarization, which in 1816 Sir David Brewster observed in *alum, muriate of soda, fluor spar, boracite, leucite, analcime* and *apophyllite.*[1] By a mode of rendering visible feeble polarized tints which Sir David Brewster had used in studying these phenomena,[2] M. Biot examined the light polarized by crystals of alum, and concluded that they were formed by successive laminæ superposed upon one another like a pile of plates, the laminæ being parallel to the faces of the octahedron. The polarized tints were exhibited in *alum containing ammonia,* but were not visible in *alum entirely free of ammonia.*

M. Biot conceives that the polarization thus produced differs from that of a pile of glass plates (or of certain crystals of nitre, or of decomposed glass) in this respect, that the polarization of the glass plate is not chromatic, whereas in alum it increases or diminishes the tints of sulphate of lime. "The difference," he says, "depends on this, that each *fuseau octaedrique* carries away from the primitive polarization a group of luminous elements associated according to certain conditions of refrangibility, impresses upon them generally a direction of polarization different from that of the artificial pile, and communicates to this group, as well as to the complementary group, certain persistent dispositions, in virtue of which they ulteriorly polarize themselves in the thin plates endowed with double refraction, as if they had traversed a plate of definite power." By supposing *apophyllite* to consist of laminæ perpendicular to an axis of double refraction, and also of laminæ parallel to the four faces of its pyramidal summit, M. Biot tries to explain the beautiful symmetrical figure which Sir David Brewster discovered in this mineral,[3] but he has not succeeded; and we are convinced that there is no such property of light as its *lamellar* polarization essentially different from the polarization of plates, and that of molecular polarization.[4]

The Abbé Moigno having taken the same view of the subject, says,—"Must we really conclude from this long study of M. Biot,[5] that the superposition of laminæ, or, as M. Biot calls it, the lamellar tissue, exerts a proper action *sui generis*, a new kind of special polarization? We say, frankly, that we do not think so. It is our profound conviction that the true cause of these anomalies is connected with the phenomena of imbibition, of temper, &c.; with the crossing of different crystallographic structures, truncations, &c.; and with assemblages in mosaic of crystals placed in varied positions, and arranged in a very complex, though very symmetrical order."[6]

In support of these views we may refer the reader to the complex structure of *fluor spar*, one of the regular octahedral crystals like alum, as discovered by Sir David Brewster by the reflection of a small pencil of light from its disintegrated surfaces, and represented in figs. 271, 272, of this article.[7]

Circular Polarization.

Art. IX.—On the Polarization produced by the Eye.

M. Haidinger of Vienna, among the many important discoveries which he has made, observed the remarkable fact, that the human eye has, in its whole structure, or in the structure of some of its parts, the property of polarizing light to such a degree as to enable us to determine by it alone the direction of the plane of polarization.

When we look carefully at light polarized by reflection or refraction, by double refraction, or by the blue sky at a point about 90° from the sun, where the polarization is greatest, we shall perceive along the axis of the eye two *sectors* or *brushes* (*houppes, aigrettes*) of *yellow* light, accompanied with other two sectors of a *bluish* light, the first two forming as it were the *first* and *third* quadrants of a circle, and the other two the *second* and *fourth.* The *yellow* sectors lie in the plane of polarization, and the *bluish* ones in a plane perpendicular to it. They are so very faint that many persons cannot see them. The sectors are seen by eyes deprived of the crystalline lens. Sir David Brewster found that they subtended an angle of 4° or 4½°, almost exactly the same as that of the *foramen centrale* in the retina with a *yellow* margin.

Two explanations have been given of this phenomenon. In the one, the coloured sectors are supposed to be produced by thin depolarizing films, which give a yellow tint which is subsequently analysed by a polarizing laminated structure within the eye; and in the other, which is that of Jamin,[8] the *yellow* light is supposed to be the colour of light polarized by refraction, and the *blue* to be the result merely of contrast. He considers the cornea alone as capable of producing the sectors.

In referring the reader for further information to the works quoted below, we may mention that the thin films which traverse the vitreous humours in all directions, and inclose the fluid in separate compartments, may be a polarizing agent in the production of the coloured sectors.[9]

Chap. II.—On Circular Polarization.

Sect I.—On the Circular Polarization in Rock-Crystal and Amethyst.

Circular polarization in rock-crystal.

The general phenomena of circular polarization were discovered by M. Arago in 1811. He found that in plates of rock-crystal the colours polarized along its axis were different from those which he had studied in plates of other crystallized bodies. When they were analysed by a prism of Iceland spar, he found that the two images had complementary colours in the ordinary tints, but, what was remarkable, they descended in Newton's scale as the prism revolved, so that if the tint of the extraordinary image was *red*, it became in succession *orange*, *yellow*, *green*, and *blue*. Hence he concluded that the differently-coloured rays had been polarized in different planes in passing along the axis of the rock-crystal.

M. Biot took up the subject at this point, and investigated it with his usual ingenuity and success. He found that while in *some* crystals of quartz the tints descended in the scale of colours, by turning the analysing prism from

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[1] See sect. xiv. of the present chapter.
[2] See *Edin. Trans.* 1816, p. 159.
[3] See *Edin. Trans.* 1822, vol. ix., p. 270, where a large coloured drawing is given of this phenomenon, of which fig. 222 is an abridgement.
[4] See Brewster's *Treatise on Optics*, chaps. xxxiii. and xxxix.
[5] *Mém. Instit.* tom. xviii., pp. 539–727.
[6] *Repertoire d'Optique*, &c., tom. i., p. 371.
[7] *Edin. Trans.* 1837, vol. xiv., pp. 164–176; or *Phil. Mag.*, Jan. 1853, p. 16.
[8] *Comptes Rendus*, &c., tom. xxvi., p. 197.
[9] See Moigno's *Repertoire*, tom. iv., pp. 1327–1366; *Phil. Trans.* 1815, p. 151, props. xxiv. and xxv.; *Reports of the British Association*, 1840 p. 6; and Brewster's *Optics*, chap. xxvii.

Circular Polarization.

right to *left*, in *others* they descended in the scale by turning the prism from *left* to *right*. The one he called left-handed quartz, and the other right-handed quartz. He took a plate of quartz, for example, $\frac{1}{25}$th of an inch thick, and having polarized the homogeneous colours of the spectrum, he transmitted them in succession along the axis of this plate, and obtained the following results:—When the analysing plate was in 0° of azimuth, the *red* light polarized by the plate was a maximum. When the analysing plate was turned from right to left, the *red* tint gradually diminished, and after a rotation of $17\frac{1}{2}°$, it wholly vanished. With a plate of $\frac{2}{25}$ths of an inch thick, the *red* tint did not vanish till after a rotation of 35°; and so on, every additional 25th of an inch of rock-crystal requiring an additional rotation of $17\frac{1}{2}°$ to make the tint vanish. A whole inch of quartz, for example, would require $25 \times 17\frac{1}{2}° = 437\frac{1}{2}°$, or one whole turn, and $77\frac{1}{2}°$ more, to cause the *red* tint to vanish. It is obvious that twenty-five plates of quartz, $\frac{1}{25}$th of an inch thick, would produce the same effect as 1 inch of it.

When *right-handed* plates, however, are combined with *left-handed* ones, the rotation produced is equal to the difference of their actions; thus a plate of left-handed quartz $\frac{1}{25}$th of an inch, combined with a plate $\frac{2}{25}$ths of an inch, would produce a rotation of only $17\frac{1}{2}°$. The following table contains the rotations produced upon the other coloured rays of the spectrum, as given by M. Biot:—

Names of the ray.	Arc of rotation for 1·25th of an inch in quartz.
Extreme red...	17°·4964
Limit of red and orange	20·4798
Limit of orange and yellow	22·3138
Limit of yellow and green	25·6752
Limit of green and blue	30·0460
Limit of blue and indigo	34·5717
Limit of indigo and violet	37·6829
Extreme violet	44·0827

M. Biot conceived that this property of quartz belonged to its ultimate molecules, but Sir David Brewster proved that this was not the case, by showing that heat deprived quartz of the property of circular polarization; and Sir John Herschel's beautiful discovery, that it was connected with the crystallization of the mineral, put this result beyond a doubt. He found that those crystals in which the plagihedral faces described by Haüy, went round the crystal from *right* to *left*, exhibited the optical properties of left-handed crystals, and these crystals in which the plagihedral faces leant round the crystals from *left* to *right* had the properties of right-handed crystals. Hence he concluded *that whatever be the cause which determined the direction of rotation, the same law acted in determining the direction of the plagihedral faces.*

When Sir David Brewster discovered the system of rings in quartz, he found the tints of circular polarization occupy, as might have been expected, the inner circle of the rings, as shown in fig. 253, only small portions of the black cross being visible; but these black portions were larger as the plate became thinner.

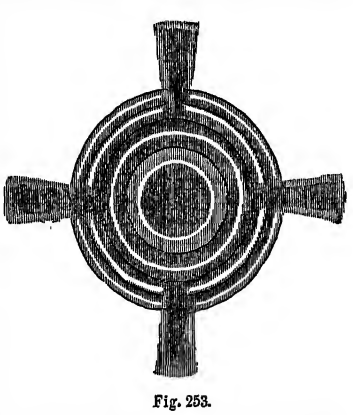

Fig. 253.

Singular properties of amethyst.

In examining the structure and properties of the amethyst, Sir David Brewster found that this singular mineral was actually composed of the two different kinds of quartz, viz., the *right-handed* and the *left-handed*. These two kinds of quartz are arranged in veins, as represented in figs. 254 and 255. In fig. 254 the shaded veins which correspond to each alternate face of the pyramid turn the planes of polarization from *right* to *left*,

Circular Polarization.

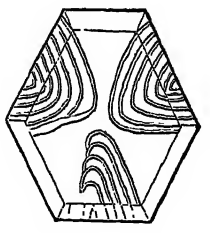

Fig. 254.

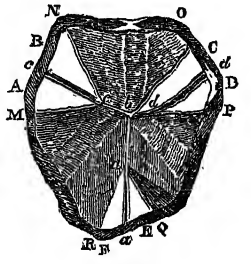

Fig. 255.

while all the rest of the crystal turns the same planes from *left to right;* and what is very interesting, the black lines where these two structures unite have no action whatever on the planes of polarization. In some specimens these opposite veins are so very minute that they destroy each other's action upon the polarized ray, and when this happens the single system of rings appears with its black cross, and entirely free of any of the tints of circular polarization. The colouring matter of the amethyst is arranged in a very singular manner in relation to these veins; and the fracture across the veins exhibits a beautiful, and sometimes a regular rippled structure, resembling the engine-turning of a watch, and affords an infallible mineralogical character of the amethyst, whether its colour is *yellow*, *orange*, *olive*, *green*, *blue*, or perfectly colourless.

The general structure of well-crystallized amethysts is shown in fig. 255, which is of the natural size, and is taken from one of the finest specimens that Sir David Brewster met with. "On the three alternate sides of the prism," says he, "viz., MN, OP, and QR, are placed sectors M*c*N, O*d*P, Q*a*R, which are divided into two parts by dark lines *cc*, *dd*, *aa*, which separate the direct structures of A, C, and E from the retrograde structures of B, D, and F. On the other three alternate faces of the prisms are placed the three veined sectors M*cba*R, N*cbd*O, and P*dba*Q, which meet at *b* in angles of 120°, and consist of veins of opposite structure, alternating with each other, and so minute that in many places the circular tints are almost wholly extinguished by their mutual action. The direct sectors A, C, and E, are all connected together by the three radial veins *ba*, *bc*, *bd*, and are therefore to be considered as the expanded terminations of these veins. The retrograde sectors B, D, and F are expansions of the first retrograde veins next to *dbc*, *dba*, and *abc*, and the lines *cc*, *dd*, and *aa* are continuations of the dark or neutral lines which separate the first retrograde vein from the direct radial veins.

"All the sectors A, B, C, D, E, and F, are of a *yellowish-brown* colour, and all the rest of the crystal is of a *pale lilac* colour, the lilac tints being arranged in the manner previously described. The phenomena which I have now mentioned as existing in this specimen are very common in the amethyst; and I have never yet found a specimen in which the yellow tints were not confined to those portions which formed the expanded terminations of veins; a fact which indicates that this would have been the colour of the crystal, whether its action were direct or retrograde, and that the lilac colour affects in general those portions which are composed of opposite veins."

Fresnel's discoveries.

The subject of circular polarization received great accessions from the genius of M. Fresnel. He conceived that a ray passing along the axis of quartz should be refracted in two pencils, and he ascertained this to be the case by the following experiment:—He took a prism ACB (fig. 256), of *right-handed* quartz, having its faces AC, BC equally inclined to its axis AB, so that a ray PV should be incident at angles of 75° on either face. As a ray, however, refracted at R would not emerge at all from the

Circular Polarization.

other side CB, he took another similar prism, but from a crystal of *left-handed* quartz, and having cut it into two halves, he placed these two halves ACD, BCE, as in the figure, so that he had an achromatic combination of three prisms. Now a ray PQ, incident perpendicularly at Q, should pass straight on without deviation, or double refraction,

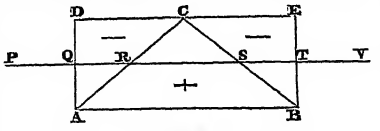

Fig. 256.

if quartz were like other uniaxal crystals. But if the pencil PQ suffer any double refraction at Q, this double refraction will be doubled at R, because ABC has an opposite kind of double refraction. The same effect takes place at C, so that the ray PQ at its emergence at T, ought to have a very sensible double refraction, even if that at Q was very small. Now M. Fresnel found that this double refraction actually existed, but upon examining the image he found that they had suffered *a new kind of double refraction*, and acquired new properties. In place of their being polarized in opposite planes, like other doubly-refracted pencils, which, when examined with a doubly-refracting prism, give two unequal images, alternating in brightness during the revolution of the spar prism, they exhibit the following properties:—

1. Either of the quartz rays, when examined with a spar prism, gave two images of equal intensity in every position of the prism. Hence they resemble unpolarized light, as if they consisted of two rectangularly polarized rays.

2. They differ from unpolarized light in having the following remarkable and characteristic property. If either of them be incident at right angles, as shown at RP (fig. 257), upon the face AB of a parallelopiped of crown-glass, having its refracting index 1·51, and its angles ABC and ADC, $54\frac{1}{2}°$, it will suffer two total reflections at Q and S, emerging perpendicularly from the surface DC in the direction ST. Now this ray ST is found to be completely polarized in a plane inclined 45° to the plane of its reflections, whatever may be the position of that plane. If the other ray is incident at *rp*, and is reflected at *q* and *s*, so as to emerge in the direction *st*, the one ray ST will be polarized in a plane 45° to the *right*, and the other *st* 45° to the *left* of the plane of reflection. Hence they emerge when superimposed in a state of common light. The two rays RP, *rp* are said to be *circularly polarized.*

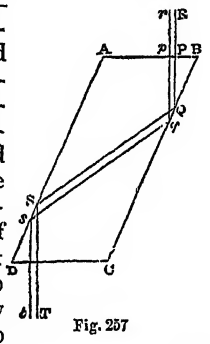

Fig. 257

3. If a ray thus circularly polarized is transmitted through a thin crystallized plate, and parallel to its axis, it is divided by double refraction into two rays of complementary tints, thus showing a decided difference from a ray of common light; and these complementary colours always differ from those that are produced from light polarized and analysed in the usual way, by an exact quarter of a tint either in defect or in excess.

4. A circularly polarized ray transmitted again along the axis of rock crystal, and subsequently analysed, produces, like common light, no colours, and differs in this respect from polarized light.

As two circularly polarized rays RP, *rp*, emerge from *Fresnel's rhomb* (as the parallelopiped of glass ABCD, fig. 257, has been called), in rays, ST, *st*, polarized $\pm\pm 45°$ to the plane of reflection, it occurred to Fresnel, and he found it to be so, that a ray TS polarized 45° to the plane of reflection in the rhomb would emerge in the direction PR, as a circularly polarized ray, possessing all the properties of one of the rays formed along the axis of quartz.

Circular Polarization.

In an extensive series of experiments, of which we shall give some account in the following chapter, Sir David Brewster had occasion to examine some of the kindred phenomena of circular polarization. His first experiments on this subject preceded those of Fresnel. He found that total reflection produced polarized tints analogous to those of crystallized laminæ, and he supposed that these colours were produced by the interference of two portions of light, the one partially reflected in the first instance, and the other beginning to be refracted, and caused to return by the continued operation of the same power.[1] In continuing his experiments, he found that the colours produced by total reflection did not rise in the scale by successive reflections; and at the end of 1816 he announced in the *Journal of the Royal Institution*,[2] that he had discovered "a new species of moveable polarization, in which the complementary tints never rise above the white (the bluish white) of the first order, by the successive application of the polarizing influence," &c. He determined experimentally the angles at which this tint was successively produced and destroyed, and thus discovered some of the leading properties of total reflection. It was Fresnel, however, that discovered this new species of polarization to be circular, and made those other splendid discoveries which we have just detailed. We owe to Sir David Brewster, however, the discovery of the inversion of the spectrum in the phenomena of total reflection, of which we shall give some account in the next chapter.

Later experiments.

In giving the name of circular polarization to that which is impressed on the two rays along the axis of quartz, M. Fresnel was guided by theoretical considerations. Mr Airy has, however, taken a different view of the condition of the light forming these two rays in quartz, and has been led to results of very high interest. The following are the experiments, which we shall give in his own words, on which he founded his deductions. They were made with a Fresnel's rhomb, fitted up as in the annexed figure, where the rhomb is shown at *rr*.

Discovery by Mr Airy.

"1. If Fresnel's rhomb, mounted as in fig. 258, be placed to receive the polarized light, so that the plane of reflection passes through the divisions 45° and 225°, the calc spar will

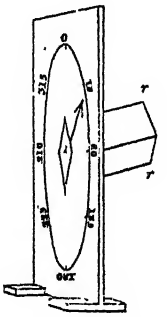
Fig. 258.

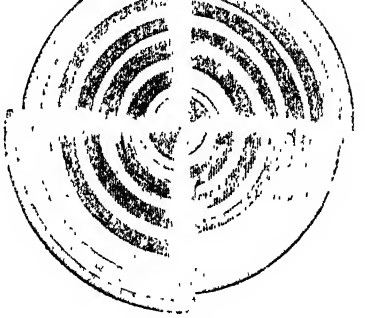
Fig. 259.

present another appearance (fig. 259). The rings are abruptly and absolutely dislocated; those in the upper right hand quadrant and the quadrant opposite to it are pushed from the centre by one-fourth of an interval, and those in the other quadrants are drawn nearer to the centre by the same quantity. The line separating the quadrants is nowhere black; the intensity of its light is uniform, and about equal to the mean intensity. If the plane of incidence pass through 135° and 315°, the phenomena of adjacent quadrants are

[1] See CHROMATICS, § xv., vol. vi., p. 657: and *Phil. Trans.* 1830, p. 310.

[2] Vol. iii., p. 213.

Circular Polarization.

exactly interchanged. No alteration is made by turning the analysing plate round the incident ray; the lines dividing the quadrants are always parallel and perpendicular to the plane of reflection at the analysing plate.

"2. If the plane of reflection in the rhomb pass through 0° and 180°, or through 90° and 270°, the phenomena are precisely the same, and undergo the same changes as those in ordinary rings. If while the plates are crossed, the rhomb be turned gradually from the position 0° towards 45°, the rings are gradually changed, at first becoming (as far as the eye can judge) elliptical, and then assuming the form represented in fig. 260.

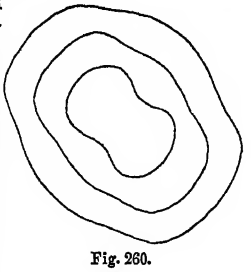

Fig. 260.

"3. If a plate of quartz, whether right or left handed, be interposed between the crossed plates, a set of rings is seen like those in fig. 253. As far as the eye can judge, the rings are exactly circular, but there is no black cross, and the central tint is not black, but removed from it by a number of tints in Newton's scale proportional to the thickness of the quartz. Thus with a thickness of 0·48 inch, the central tint is pale pink; with a thickness 0·38 inch, the central tint is bright yellowish-green; with thickness 0·26 inch, it is a rich red plum colour; with thickness 0·17 inch, it is a rich yellow.

"The colours then appear to be nearly the same, beginning from the centre, as in Newton's scale, beginning with the tint representing this central tint. At a considerable distance from the centre four dark brushes begin to be visible in the same direction as the arms of the black cross in calc spar.

"4. Now (supposing the crystal right-handed), if the plate of quartz be thin, and the analysing plate be turned, the upper part towards the observer's left hand, a bluish short-armed cross appears in the centre, which, on turning further, becomes yellow, and the rings are enlarged. On turning still further, the cross breaks into four dots. The rings are no longer circular, but of a form intermediate between a circle and a square, their diagonals (as well as the cross) being inclined to the left of the parallel, and perpendicular to the plane of reflection (see fig. 261). If the analysing plate be turned the other way, there is no cross; the form of the rings is changed from circular nearly as in the former case.

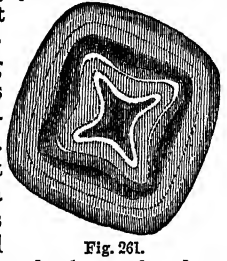

Fig. 261.

"5. If the plate of quartz be thick, the dilatation of the rings, and the change of form, are all the perceptible phenomena; and on turning the analysing plate continually to the left, the rings continually dilate, and new spots start up continually in the centre and become rings. If the crystal be left-handed, the remarks in this and the last article apply equally well supposing the analysing plate turned in the opposite direction.

"6. If Fresnel's rhomb be placed in the position 45°, and the light thus circularly polarized pass through the quartz, on applying the analysing plate instead of rings, there are seen two spirals naturally inwrapping each other, as in fig. 262. If the rhomb be placed in position 135°, the figure is turned through a quadrant. If the quartz be left-handed, the spirals are turned in the opposite direction. The central tint appears to be white. With the rhomb which I have commonly used (which is of plate-glass, but with the angles given by Fresnel for crown-glass), there is at the centre an extremely dilute tint of pink. I think it likely that this arises from the cross in the angles, as the intensity of the colours have no proportion to that in other parts of the spirals. The figure was drawn from the appearances given by a plate of quartz 0·26 inch thick.

Circular Polarization.

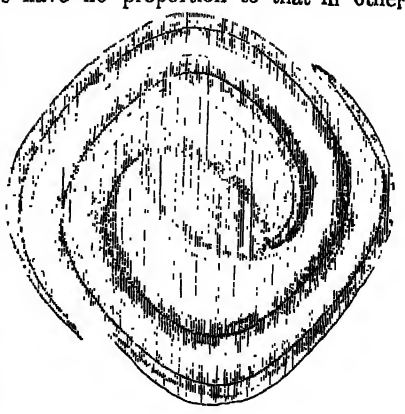

Fig. 262.

"7. If two plates of quartz of equal thickness, but cut, one from a right-handed, and the other from a left-handed crystal, be attached together, and put between the polarising and analysing plates, the left-handed slice nearest to the polarizing plate, the appearance presented is that of fig. 263. Four spirals (proceeding from a black cross in the centre, which is inclined to the plane of reflection) cut a series of circles at every quadrant. The points of intersection are in the plane of reflection, and perpendicular to it. This is the simplest way of describing the form; but if we followed the colours which graduate most gently, we should say that the form of each is alternately a spiral and circular arc, quadrant after quadrant.

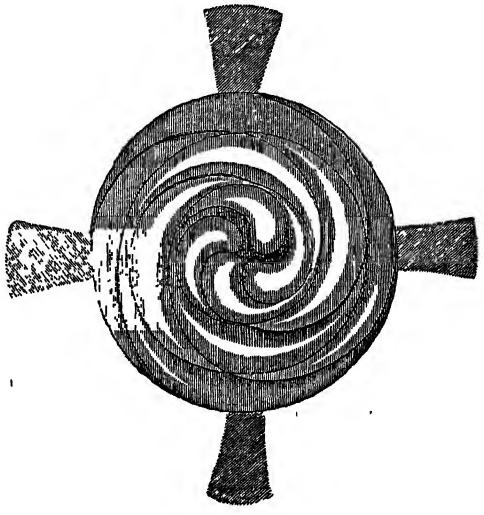

Fig. 263.

"At a distance from the centre, the black brushes are seen. If the combination be turned, so that the right-handed slice is nearest to the polarizing plate, the spirals are turned in the opposite direction. This is one of the most beautiful phenomena of optics. The slices from whose appearance the figure was drawn, are each 0·16 inch thick."

When the temperature of the two plates of quartz is greatly increased, the system of rings suffers certain changes which have not yet been carefully examined.

The rotatory force of quartz was found by M. Dubrunfaut to be increased 1° 50′ by an additional temperature of 70° centigrade. With a spirit-lamp he succeeded in raising it 12°.

The preceding phenomena are described as they appear when examined with an analysing plate of unsilvered glass. The following are the theoretical views which Mr Airy considers as consonant with these experiments. They had been originally suggested to him by the desire of finding some connecting link between the peculiar double refraction in quartz, and the common double refraction:—

"1. I suppose the ordinary rays to consist of light ellip-

Circular Polarization.

tically polarized, the greater axis of the ellipse being perpendicular to the principal plane; and the extraordinary rays to consist of light elliptically polarized, the greater axis of the ellipse being in the principal plane.

"2. I suppose that when the ordinary ray is right-elliptically polarized, the extraordinary ray is left-elliptically polarized, and *vice versâ*.

"3. I suppose that the proportions of the axes of the two ellipses are the same, each proportion being one of equality when the direction of the ray coincides with the axis, and becoming more unequal, according to some unknown law, as the direction is more inclined to the axis; the minor axes of the ellipses having sensible magnitudes when the rays are inclined 10° to the axis.

"4. I suppose that the course of the rays after refraction can be determined by the construction given by Huygens for calc spar, with this difference only, that the prolate spheroid for determining the course of the extraordinary ray must not be supposed to touch the sphere for determining the course of the ordinary ray, but must be entirely contained within it."

In a supplement to his investigations, Mr Airy remarks, that he has not yet ascertained the law which connects the ellipticity of the rays with the angle that they make with the axis. He considers, however, the following points as made out:—

"One of the rays is certainly right-handed elliptical, and the other certainly left-handed elliptical. The major axis of one is certainly perpendicular to the principal plane of the crystal, and the major axis of the other is certainly in that plane. Mr Airy remarks, that in some trials for measuring the ellipticities of the rays, he seems to have arrived at the conclusion, that the proportion of the axes of the ordinary ray is more nearly one of equality than the proportion of the axes of the extraordinary ray."

Professor Maccullagh.

This subject has subsequently been investigated by Professor Maccullagh, whose object was to pave the way for a mechanical theory, by showing that all the phenomena may be grouped together by means of a simple geometrical hypothesis. Setting out from this hypothesis, he arrives immediately at all the known laws, and obtains at the same time a law that was previously unknown, and which is technically called the *law of ellipticity*. By this law Professor Maccullagh has been able to compute the ellipticities observed by Mr Airy in rays inclined to the axis of quartz, from the angles of rotation observed by M. Biot in rays parallel to that axis.[1]

M. Jamin.

In order to explain the phenomena of quartz, it was necessary to determine the ratio of the axes in each of the ellipses of the two refracted rays at different inclinations to the axes, and also the difference of the velocities of the two rays. This has been done by M. Jamin in an interesting memoir.[2] The following are the ratios of the axes:—

Inclination to the Axis.	Ratio of the Axes.	Inclination to the Axis.	Ratio of the Axes.
1°	1·000	15°28′	0·125
2	0·939	19 42	0·087
5 17′	0·641	24 30	0·052
9 15	0·309		

The following results express in a fraction of the length of an undulation the difference of velocity of the two elliptical rays in a plate of quartz cut perpendicular to the axis, and the 25th of an inch thick.

Inclination to the Axis.	Difference of Velocity.	Inclination to the Axis.	Difference of Velocity.
0°	0·120	20°27′	0·219
5 26′	0·135	25 17	1·231
11 0	0·273	30 26	1·774
15 33	0·490	35 3	2·287

Having obtained these measures, M. Jamin requested M. Cauchy to apply to them his general theory of double refraction. Without knowing the experimental results, this distinguished mathematician, whose recent loss science is now deploring, solved the problem; and M. Jamin, by a few hours' calculation, ascertained that the theory reproduced the facts with such marvellous exactness, that it was not necessary either to modify the formulæ, or to endeavour by new experiments to make them coincide with the theory.

Circular Polarization.

Circular polarization has been discovered by Sir David Brewster in plates of glass possessing the doubly-refracting structure. M. Dove of Berlin has found it also in compressed glass.[3]

Sect. II.—On the Circular Polarization of Fluids.

Circular polarization in fluids.

Although this remarkable property was discovered in some fluids by M. Seebeck by independent observation, yet M. Biot had anticipated him in it, and has made this subject so completely his own, by a series of the most elaborate and beautiful researches, that if he had done nothing else for science, they would have ensured him a high reputation. We regret extremely that our limits will not permit us to give anything like a full and satisfactory account of his discoveries, particularly those contained in his valuable paper of 1832. We must therefore refer the reader to his original memoirs, and give in as abridged a form as possible his leading results.

M. Biot discovered that some fluids turn the planes of a polarized ray from right to left, and others from left to right. He found also that the tints rose in the scale, as in quartz, by an increase in the thickness of the fluid. The following table contains some of his results:—

I. *Fluids that turn the Plane of Polarization from Left to Right.*

Fluids.	Colours.	Arcs of rotation with the red rays, with a thickness of 200 millimetres.
Oil of fennel seeds	Palish-green	26°·32
„ caraway seeds	Colourless	131 ·58
„ lavender	Greenish	4 ·04
„ rosemary		6 ·58
„ marjoram	Orange-yellow	23 ·68
„ sassafras	Yellow	7 ·06
„ savine	Yellow	14 ·12
„ bitter oranges	Greenish-yellow	157 ·89
„ bergamot	Colourless	38 ·16
„ lemons	Colourless	110 ·53
Neroli, common	Yellow	$\frac{1}{2}$ths of oil of oranges.
„ fine	Orange-yellow	do.
„ superfine	Reddish	$\frac{5}{8}$ths of com. neroli.

II. *Fluids that turn the Plane of Polarization from Right to Left.*

Essential oil of turpentine	Greenish	59°·21
Naphtha	Greenish	15 ·21
Oil of anise seeds	Greenish	1 ·51
„ mint	Limpid	32 ·28
„ rhue	Yellowish	conjectured.

Oil of mustard and oil of *bitter almonds* exercise no action upon polarized light.

Camphor

M. Biot found that in a solution of *natural camphor* in alcohol, in which there was 0·37117 of camphor in weight to 1 of the solution, and its density 0·87221, the rotation for red light, and a thickness of 152 millimetres was 17°·56 from *left to right*. A solution of *artificial camphor* in alcohol, on the other hand, with 0·0917 of camphor to 1 of the solution, and having its density 0·8455, and in a thickness of 1357 millimetres, produced only a rotation of

[1] *Report of the British Association* for 1836, p. 18.
[2] *Comptes Rendus*, tom. xxx., p. 99; and Moigno, *Repertoire*, &c., tom. iv., pp. 1502–1510.
[3] This memoir has been translated and published in Taylor's *Scientific Memoirs*, vol. i., part i., p. 75.

Circular Polarization.

24°, but in the opposite direction, from *right to left*. In *gum from Senegal*, of which 47·4 parts was dissolved in 99·1 of distilled water, there was a rotation from right to left of 12° 13′ 20″, with a thickness of 152 millimetres.

The following table contains the results which our author obtained from different kinds of sugar:—

From Left to Right.

	Proportion of sugar in 1 of the solution.	Density.	Arc of rotation of red light in a thickness of 152 millimetres.	Molecular power of rotation.
Sugar of canes, syrup of	0·25	1·1052	23° 28′ 45″	83° 94
Ditto ditto	0·50	1·2311	52 7 30	
Ditto ditto	0·65	1·3114	70 11 15	
Sugar of milk	0·14	1·0537	10 21 40	70·18
„ starch	0·65	1·2460	48 30 0	59·99
Crystallizable principle of honey	0·34	1·1329	16 47 30	43·32
Sugar of grapes	...	...	...	59·10

From Right to Left.

The rotation being observed for the yellow rays, and the thickness of solution 152 millimetres as before.

Sugar of grapes in syrup	10°	0′	0″
Uncrystallizabl eprinciple of honey, alcoholic solution	3	38	20
The same dry	11	15	0

M. Soubeiran found that honey contains three different kinds of sugar,—one like common sugar; another, which is liquid, and which turns the planes of polarization to the *left*; and a third kind, which gives a rotation to the *right*.

M. Biot made experiments with various vegetable juices, all of which give a slight rotation from *right to left*.

	Thickness of fluid.	Rotation
Juice of grapes, white	160 millimetres	6°
Do., red and white mixed	160 „	6·25
Chasselas	160 „	5·50
Muscat	160 „	5·33
Verjuice	160 „	1·81
Chasselas of Fontainbleau	160 „	8·00
Common black grape	160 „	10·00
Apples for cider	„	3·33
Red gooseberries, very ripe...	80 „	1·81
Berries of the service tree	160 „	2·5

M. Biot also found that claret, white champagne, alcohol, sulphuric ether, citric acid dissolved in the proportion of 30 to 37 of water, sulphuric acid pure and colourless, and olive oil, produced no effect upon polarized light.

He found, however, that tartaric acid dissolved in the proportion of 53 of acid to 52 of water produced a rotation of 8° *from right to left*.

Dextrine.

One of the most curious discoveries contained in M. Biot's memoir is that of the powerful rotatory property of *dextrine*, an uncrystallizable syrup which is found in the farina of rice, wheat, and even of ligneous tissue.[1] It differs from gum in producing an opposite rotation, and from sugar in its superior power of rotation, which is almost triple of that which is exerted by sugar of canes. It surpasses all animal and vegetable substances at present known, at equal densities and thicknesses, in turning round the plane of a polarized ray,—rock-crystal only being superior to it. The name of dextrine has been given to it in order to mark the direction as well as the powerful energy of its force of rotation.

M. Biot and M. Persoz more recently found a sugar of starch whose power of rotation is almost equal to that of crystallized sugar of canes. They also discovered, that when sugar of canes is dissolved in water mixed with dilute sulphuric acid, and heated below the boiling point, it loses its power of turning the planes of polarization from left to right, like sugar of grapes not solidified. Sugar of starch submitted to the same process did not experience this inversion. M. Biot likewise found that the coloration of liquids did not exercise any influence on their rotatory property.

Circular Polarization.

In a series of experiments on the six vegetable alkalis, *morphine*, *narcotine*, *strychnine*, *brucine*, *quinine*, and *cinchonine*, dissolved in alcohol or ether, M. Bouchardat found that all of them except *cinchonine* had − or left-handed circular polarization. The + rotatory force of *cinchonine* was very great. By the intervention of an acid the rotatory force was modified in all of them except *morphine*. The influence of acids upon *narcotine* was enormous. Its rotatory force in alcohol and sulphuric ether is −151°·4, in alcohol 100°, and in chlorohydric acid it is +83°. The rotatory force in *brucine* is diminished by acids and increased by ammonia.

When camphoric acid was dissolved in alcohol, and examined in a tube of 299 millimetres, its rotation was + 12° to the right. When the rotation was +38°·875, it was greatly diminished by saturation with an alkali, and restored by the addition of an excess of strong acid.

Previous to these experiments tartaric acid was the only acid known to have a rotatory power; but its great power of dispersing the colours of the spectrum prevents it from being employed in the researches of mechanical chemistry, and consequently M. Bouchardat's discovery of the rotatory force of camphoric acid is of great importance.[2]

Influence of heat.

The influence of heat on the rotatory force of fluids was first observed by M. Mitscherlich in solutions of common sugar. M. Dubrunfaut found that the same effect was produced in solutions of *dextrine*, *glucose*, and the sugar of fruits, and that a sufficient quantity could change the direction of polarization from left to right. The rotatory force of cane sugar is diminished 0·0232 by 100° of temperature from 0° to 100°. Glucose, in solution, has its force diminished 0·0462 by the same increase of heat. Dextrine also loses $\frac{7}{100}$ths of its rotatory force by a rise of temperature.

A very ingenious method of magnifying weak rotatory forces, such as those of vegetable juices, has been proposed by M. Botzenhart. It is founded on the law of the rotation of the plane of polarization by refraction, established by direct experiment by Sir David Brewster.[3] When a polarized ray, which has experienced from the action of a fluid a small rotation, is made to pass through one or more plates of glass, its initial or primitive rotation will be greatly magnified. If φ be the initial angle required, when a is the angle or change produced by one or more plates by refraction at an incidence i, and if r be the angle of refraction, and m the number of plates, then we shall have

$$\text{Tan } \varphi = \frac{\tan a}{\cos^2 m\,(i-r)},$$

Making the index of refraction m of glass = 1·5, $a = 30'$, and $i = 70°$, we shall have

$\varphi = 0°\ 56'\ 4''$ for 2 plates.
$\varphi = 1\ 44\ 46$ for 4 plates.
$\varphi = 6\ 4\ 40$ for 8 plates.

If $a = 15'$ and $i = 70°$, then we shall have

$\varphi = 0°\ 52'\ 24''$ for 4 plates.
$\varphi = 3\ 2\ 50$ for 8 plates.

Sect. III.—On the Crystallographic Structure which produces Circular Polarization.

When M. Biot discovered right and left handed quartz,

[1] Dextrine may be procured from laundry starch by hot or cold acids, by potash, or by hot water, any one of which will rupture the envelope and set free the dextrine.

[2] M. Bouchardat found that amygdalic acid has the same rotatory power as the tartaric.

[3] *Phil. Trans.* 1830, p. 136, and p. 642 of this article.

Circular Polarization.

he made the first step in this inquiry; and another step was made when Sir David Brewster discovered that the property of circular polarization did not, as M. Biot supposed, belong to the ultimate molecules of quartz. An additional step was made when Sir John Herschel discovered the connection between the plagihedral faces of quartz and the direction of the rotatory force. Another step was taken in this inquiry when Sir David Brewster discovered *that amethyst was composed of right and left handed quartz, the rotatory force of the one destroying the equal rotatory force of the other, while in certain portions symmetrically placed in the crystal, each variety of quartz exercised separately its full power of rotation.* These last portions, shown at A, B, C, D, E, and F, in fig. 255, are so large in the specimen from which that figure was drawn, that a lapidary could have cut them out, and exhibited the plates A, C, and E as *right-handed* quartz, and B, D, and F as *left-handed* quartz. Nay, if there had been a proper solvent for *amethyst*, separate crystals of *right* and *left handed quartz* could have been obtained from the solution. We mention these facts because a sufficiently important place has not been assigned to them either by M. Biot or M. Pasteur in their reports and memoirs on the analogous properties discovered by the latter in the *tartaric* and *racemic* acids, and their derivative salts. These properties we shall now proceed to describe.

The solutions of *tartaric acid*, with all the *tartrates*, in water, turn the planes of polarization from *left* to *right*; but the *tartrate of lime* in *chlorohydric acid* turns these planes to the left. In 1844 M. Mitscherlich showed that the double *tartrates* and *para-tartrates of soda* and *ammonia* have the same chemical composition, the same crystalline form, with the same angles, the same specific weights, the same double refraction, and consequently the same inclination of their optical axes. Notwithstanding this similarity, M. Biot found that the whole series of the *tartrates* turned the planes of polarization to the right, while the *para-tartrates* exercised no rotatory action whatever.

This interesting subject has been successfully studied by M. Pasteur. He has found that the *para-tartaric acid*, which is exactly the same as the *racemic acid*, and which differs from the *tartaric* only in having an additional atom of water, is actually composed of two distinct acids, one of which, the *levo-racemic*, has a rotatory force from left to right, and the other, the *dextro-racemic*, from right to left, the rotatory force of both being the same. Hence it follows, that when these two acids are combined, as they are in the *para-tartrate* and racemates, the two opposite forces compensate one another. The *dextro-racemic acid* is therefore identical with the common *tartaric acid*, and the dextro-racemates are nothing more than tartrates.

In comparing the rotatory forces of these salts with their crystalline forms, M. Pasteur has found that the *tartrates* or *dextro-racemates* have plagihedral forces going from *left to right*, while the *levo-racemates* have their plagihedral forces going from *right* to *left*, and the *para-tartrates* and *racemates*, like *amethyst*, consist of the two combined. So far, then, the researches of M. Pasteur are analogous with those which determined the relations of quartz to amethyst.

The subsequent researches of M. Pasteur, however, are equally interesting. When crystals are formed, according to the theory of Haüy, by the aggregation of infinitely small solids of the same form, they must necessarily be symmetrical. Haüy himself had recognised several exceptions to this law of symmetry; but it is to M. Weiss that we owe the generalization of these exceptions, to which he gave the name of *hemihedral*. In studying the physical relations of *hemihedral* crystals, M. Pasteur has divided them into two great classes, which he calls *superposable* and *non-superposable*. When a crystal is *hemihedral*, we may, in certain cases, imagine another crystal identical with that crystal in all its parts, but which is *not* superposable, just as our right hand, though identical with the left, is *not superposable* upon it. On the other hand, all regular *tetrahedrons*, and all *rhombohedrons* of the same angle, are *superposable* hemihedral forms. The two plagihedral varieties of quartz, the tartrates, the *para-tartrates* or *racemates*, *asparagine* and *aspartic acid*, and the combinations of *glucose* with sea-salt, are examples of *non-superposable hemihedral* crystals, and have all circular polarization. In the *superposable* hemihedral crystals, the rotatory polarizing power has never been found; and there are only two exceptions to its existence in the *non-superposable hemihedral* crystals. These exceptions, according to M. Pasteur, are *formiate of strontian* and *sulphate of magnesia*, both biaxal crystals, and both *non-superposable* in their hemihedral forms.

Circular Polarization.

In all the crystallizations of the *formiate of strontian* M. Pasteur found two species of crystals, the one *hemihedral to the right*, and the other *hemihedral to the left*, perfectly identical, but *not superposable;* and yet the solutions of neither have circular polarization; though, when crystallized anew, they again yield the two species of crystals. In explanation of this unexpected result, M. Pasteur supposes that the *hemihedrism* of the *formiate* does not depend on the arrangement of atoms in the chemical molecule, but on the arrangement of the physical molecules in the entire crystal, so that the crystalline structure at once disappears in the solution, as that of quartz does in fusion. The want of circular polarization in *sulphate of magnesia* M. Pasteur supposes may be owing to its being *very nearly superposable*, as the angle of the prism of this sulphate and its isomorphous bodies is between 90° and 91°; so that the right rhomboidal prism is very near the prism with a square base, which is a superposable form, and therefore should have no circular polarization.

Dr Marbach.

In examining chlorate of soda and other tessular salts, Dr Marbach of Breslau found that when dissolved in water it exhibited no trace of circular polarization. When crystals, however, were obtained from the solution, he found that they produced both left-handed and right-handed rotations. When either of these kinds was dissolved and recrystallized, they produced both left-handed and right-handed crystals. These crystals are almost always without hemihedral faces, but yet they sometimes occur; and when they do, they always possess the character of non-superposable hemihedrism. The following are the rotations which he observed in a thickness of *one* Paris line or 2·256 millimetres:—

	Rotation.	Ratio to Quartz.
Chlorate of soda	8°·2	$\frac{1}{6·6}$
Bromate of soda	6·3	$\frac{1}{8·6}$
Acetate of uranium and soda	4·0	$\frac{1}{13·5}$
Sulph. antimoniate of soda[1]	6·0	

M. Marbach has given the following method of making the crystals assume the hemihedral faces:—"Cut with a knife the angles and the edges, and then place the crystal, thus mutilated, into a saturated solution of the same salt. The crystal in its growth will form new faces, which present the *non-superposable* hemihedrism analogous to the direction of its circular polarization."[2]

In chlorate of soda M. Marbach has never found a single exception to this law, though he has examined several hundreds of crystals.

[1] 2·66 millimetres thick.

[2] See Poggendorff's *Annalen*, 3d series, tom. clxi., p. 12, 1853; *Comptes Rendus*, 1855, tom. xl., p. 795; xliii., p. 705; xlv., p. 705, 1857.

Elliptical Polarization.

M. Marbach has recently found that the thermo-electric properties of certain bodies are related to the hemihedrism of their crystals. Sulphuret of iron and gray cobalt are among the number.

The phenomena of circular polarization have already had many useful applications. M. Biot and M. Pasteur have shown, in their valuable memoirs, their application to crystallography and chemistry. M. Biot has pointed out their value in determining the state of the sap in grasses and growing corn at different stages of their growth; and by the saccharimeter of M. Soleil we can ascertain, with the minutest accuracy, the quality and quantity of sugar in any sacchariferous solution.

Sect. IV.—On the Circular Polarization of Heat.

It has been shown by MM. Biot and Melloni that quartz exercises upon polarized heat the same rotatory power which it exercises upon polarized light. In a series of very interesting experiments MM. Provostaye and Desains have shown that the essence of turpentine exercises a rotatory power over the heat which accompanies the extreme red ray and the green rays of the spectrum. The following are some of the results which they obtained:—

Essence of Turpentine; Tube 0·05 millimetre long.

Optic rotation of the red luminous ray	14° 0′
Rotation of the calorific ray which accompanies it.	11 26

Essence of Turpentine; Tube 0·1 millimetre long.

Optic rotation of the extreme red ray	28° 0′
Rotation of the calorific ray which accompanies it.	23 30

With a very concentrated solution of cane-sugar in a tube 0·05 millimetre long, they found that

For extreme red light the rotation was	25° 0′
For the calorific ray	22 36

When the syrup was divided into two exactly equal parts, and when one of these parts was replaced in the tube, and the tube filled up with distilled water, the following results were obtained:—

For the extreme red light	12° 30′
For the calorific ray	11 20

Hence it follows that the laws of circular polarization are identical for light and heat, and that which is true for a ray of the luminous spectrum is true also for the calorific ray which accompanies it.[1]

Chap. III.—On Elliptical Polarization.

Sect. I.—On Metallic Polarization.

Metallic polarization.

The phenomena and laws of elliptical polarization, as they are at present known, have been investigated only by Sir David Brewster. This species of polarization forms the connecting-link between *plane polarization* and *circular polarization*, passing nearly into the former when exhibited by *galæna*, and into the latter when exhibited by *silver*.

Sir David Brewster found at an early period, what Malus had previously observed, that the light reflected from metals was polarized in different planes. The former, however, found that the pencil polarized in the plane of reflection was always more intense than that polarized in a perpendicular plane, and which he conceived had entered the metal and been partially absorbed. He found the difference between the intensities of these pencils to be least in silver and greatest in galæna, metals which had an intermediate effect being arranged as in the following table:—

Elliptical Polarization.

Order in which the Metals Polarize most Light in the Plane of Reflection.

Galæna.	Zinc.	Brass.
Lead.	Speculum metal.	Grain-tin.
Gray cobalt.	Platinum.	Jewellers' gold.
Arsenical cobalt.	Bismuth.	Fine gold.
Iron pyrites.	Mercury.	Common silver.
Antimony.	Copper.	Pure silver.
Steel.	Tin-plate.	Tot. refl. from glass.

He found also that, by increasing the number of reflections, *the whole of the light could be polarized in one plane.* The white light of a wax candle, 10 feet distant, is polarized by *eight* reflections from *steel* between 60° and 80°, whereas it requires more than *thirty-six* from *silver*, and in total reflection where the elliptical polarization becomes circular; and when the two pencils are equal, the total polarization of the pencil cannot be effected by any number of reflections.

The action of metals upon polarized light presents us with a series of very extraordinary phenomena. One of the first of these which was discovered by our author was the action of successive reflections from silver and gold upon polarized light. These reflections are made from two metallic plates placed between the polarizing and analysing plate or rhomb, and when the plane of metallic reflections is parallel or perpendicular to the plane of primitive polarization, its azimuth will be 0°, 90°, 180°, &c.; and when it is inclined 45° to that plane, its azimuth will be 45°, 135°, &c.

In azimuth 0° no colours are observed by reflections from two plates of silver placed parallel to one another, just as in the case of crystallized laminæ whose axes are in 0° of azimuth.

At 45°, 135° of azimuth, the most brilliant complementary colours are seen, either by turning round the analysing plate, or by using a rhomb of spar that gives two images. These colours become fainter and fainter while the azimuth changes from 45° to 90°, or from 45° back to 0°, exactly like those of crystallized laminæ.

When a small number of reflections are used, the tints are fainter and less brilliant, and they increase with the number of reflections. There is an angle of reflection, about 75°, at which the tints are brightest, and they become fainter as the reflections are performed at greater or at less angles.

All the other metals in the preceding table, as well as total reflection from glass, give analogous colours, but they are most brilliant in silver, and diminish towards galæna.

Now, it is obvious that at about 75° of incidence (if we suppose the metal to be steel) the polarized light which it reflects has acquired some new physical property.

1. It is neither *common light* nor *partially-polarized* light, because if we reflect it a second time at 75° *it is restored* to light polarized in one plane.

2. It is not polarized light, because it does not vanish during the revolution of the analysing rhomb.

In order, then, to discover its nature, let it be transmitted along the axis of Iceland spar. The common uniaxal

[1] See *Ann. de Chim.*, &c., Nov. 1850; and *Phil. Mag.*, June 1851, p. 466.

Elliptical Polarization.

system of rings is changed into that shown in fig. 264, which is similar to the effect produced by crossing the uniaxal system of rings with a thin film polarizing the pale blue of the first order. If we substitute for the Iceland spar films of sulphate of lime, we shall find that their tints are increased or diminished according as the metallic action coincides with or opposes that of the crystal. This experiment led our author into the erroneous opinion that metals acted like crystallized plates; but when he found that a second reflection at 75° destroyed the effect of the first reflection, he saw that this opinion was untenable, and was led to consider the phenomena as having some resemblance to those of circular polarization.

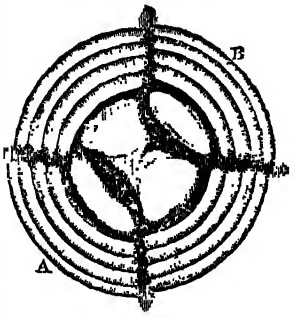

Fig. 264.

We have already seen that a circularly-polarized ray RP (fig. 257) emerges after two total reflections in the direction ST, polarized 45° to the plane of the two reflections in every azimuth. Now, if we reflect a ray of light R (fig. 265), polarized + 45° at Q, from one plate of *silver* CD, the rays QS will have acquired a property analogous to that of circular polarization; for if it is reflected a second time at S, the reflected ray ST will emerge polarized 39° 48′ to the plane of reflection. Now the difference between this result and that from total reflection is, that one reflection from silver impresses the same character upon light, whereas in total reflection two reflections are necessary. Another point of difference is, that when the ray is restored by the same number of reflections, it is not wholly restored to a plane −45°, but only to a plane −39° 48′. But there is another difference of a very interesting kind. In circular polarization the ray has the same properties on all its sides, and the angles of reflection at which it is restored to polarized light in different azimuths are all equal to the radii of a circle described round the rays. "Hence," says our author, "without any theoretical reference, the term *circular polarization* is, from this and other facts, experimentally appropriate.[1] In like manner, *without referring to the theoretical existence of elliptical vibrations* produced by the interference of two rectilineal vibrations of unequal amplitudes, we may give to the new phenomenon the name of *elliptic polarization*, because the angles of reflection at which this kind of light is restored to polarized light may be represented by the variable radius of an ellipse."

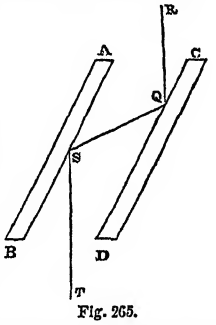

Fig. 265.

Now it is a curious fact, that while silver restores the ray to angles of 39° 48′, other metals restore it to angles deviating more and more from 45°, as is shown in the following table:—

	Inclination of Restored Ray.		Inclination of Restored Ray.
Total reflection from glass	45° 0′	Bismuth	21° 0′
Pure silver	39 48	Speculum metal	21 0
Common silver	36 0	Zinc	19 10
Fine gold	35 0	Steel	17 0
Jewellers' gold	33 0	Iron pyrites	14 0
Grain-tin	33 0	Antimony	16 15
Brass	32 0	Arsenical cobalt	13 0
Tin-plate	31 0	Cobalt	12 30
Copper	29 0	Lead	11 0
Mercury	26 0	Galæna	2 0
Platina	22 0	Specular iron	0 0

Hence it appears that the elliptic polarization passes into circular nearly in the case of *silver*, and into plane polarization in the case of *galæna;* the ellipsis becoming nearly a *circle* in the former case, and a *straight* line in the latter. Elliptical Polarization.

As light polarized + 45° suffers different degrees of elliptical polarization by one reflection from metals, and is restored again to polarized light, though in different planes, by a second reflection, so it exhibits the same phenomena at 3, 5, 7, 9, &c., in reflections, and is restored to polarized light by 4, 6, 8, 10 reflections at the same angle. The following table shows the inclination of the plane of polarization of the restored ray to the plane of reflection, in various numbers of reflections from silver and steel.

Number of Reflections.	Inclination of the Plane of the Polarized Ray. Steel.	Silver.
2	−17° 0′	−38° 15′
4	+ 5 22	+31 52
6	− 1 38	−26 6
8	+ 0 30	+21 7
10	− 0 9	−16 56
12	+ 0 3	+13 30
18	− 0 0	− 6 42
36	0 0	0 47

These results show in the clearest manner the reason why common light is polarized by eight reflections from *steel*, and not till after 36 reflections from silver; the planes of inclination of the two rectangularly-polarized rays requiring in each case that number of reflections to bring them into a state of parallelism.

The angle at which elliptical polarization is produced by one reflection may be regarded, in the present state of our knowledge of the subject, as the angle of maximum polarization, and its tangent as the index of refraction of the metal, as given in the following table:—

Name of Metal.	Angles of Maximum Polarization.	Index of Refraction.
Grain-tin	78° 30′	4·915
Mercury	78 27	4·893
Galæna	78 10	4·773
Iron pyrites	77 30	4·511
Gray cobalt	76 56	4·309
Speculum metal	76 0	4·011
Antimony melted	75 25	3·844
Steel	75 0	3·732
Bismuth	74 50	3·689
Pure silver	73 0	3·271
Zinc	72 30	3·172
Tin-plate, hammered	70 50	2·879
Jewellers' gold	70 45	2·864

We may produce elliptical polarization by a sufficient number of reflections at any given angle, in the same manner as in plane polarization. The following table contains the results of observations made with *steel*:—

Number of Reflections at which Elliptical Polarization is produced.	Number of Reflections at which the Pencil is Restored to a Single Plane.	Observed Angle of Incidence.
3, 9, 15, &c.	6, 12, 18, &c.	86° 0′
2½, 7½, 12½, &c.	5, 10, 15, &c.	84 0
2, 6, 10, &c.	4, 8, 12, &c.	82 20
1½, 4½, 7½, &c.	3, 6, 9, &c.	79 0
1, 3, 5, &c.	2, 4, 6, &c.	75 0
1½, 4½, 7½, &c.	3, 6, 9, &c.	67 40
2, 6, 10, &c.	4, 8, 12, &c.	60 20
2½, 7½, 12½, &c.	5, 10, 15, &c.	56 25
3, 9, 15, &c.	6, 12, 18, &c.	52 20

At an incidence of 67° 40′ elliptical polarization is produced by 1½, 4½, 7½ reflections. Hence we draw the interesting conclusion, that the ray must have completed its elliptical polarization in the middle of the *second* and *fifth* reflections; that is, when it had reached its greatest depth within the metallic surface. It then begins to resume its state of polarization in a single plane, and recovers it at the end of the 3d, 5th, and 7th reflection. Another very interesting effect is produced when one reflection is made on one side of the polarizing angle, and the other reflection on the other side. A ray that has been partially elliptically

[1] See Sir John Herschel's *Treatise on Light*, § 1050.

Elliptical Polarization.

polarized by one reflection at 85° does not, as in plane polarization, acquire more by a reflection at 54°, but it retraces its course, and recovers its state of single polarization.

We have seen that by *two* reflections there is only *one* angle—viz., 73° for silver—at which the elliptically-polarized ray can be restored to plane polarization. At *three* reflections there are *two* angles—viz., 63° 43′, and 79° 40′—at which the restoration can take place; at *four* reflections, *three* angles; and so on. This phenomenon is exhibited to the eye in fig. 266, where the concentric arches I-I, II-II, &c., repre-

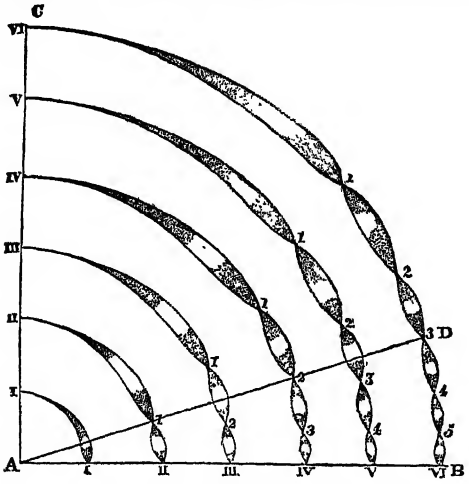

Fig. 266.

sent the quadrant of incidence from *one*, *two*, &c., reflections, B being the point of 90° and C that of 0°. The point D on the line A is the point or line of maximum elliptic polarization,—viz., 73° for silver; and the figures 1, 2, 3, 4, 5, indicate the points or nodes of restoration, and their distances from C the corresponding angles of incidence at which the restoration takes place. The loops or double curves lying between the points 1, 2, 3, &c., are drawn to give an idea of the intensity of the elliptic polarization, which has its minimum at 1, 2, 3, &c., and its maximum at the white intermediate parts. These points of maximum intensity do not bisect the loops, or are not equidistant from the minima; but such is their relation that the *maximum* for n reflections is the minimum for $2n$ reflections. These phenomena lead us to the explanation and analysis of the complementary colours which accompany elliptical and circular polarization.

Sect. II.—On the Colours of Elliptical and Circular Polarization.

Colours of elliptical and circular polarization.

When the preceding experiments are made with homogeneous light, we find that the points and angles of restoration vary for the differently coloured rays. Thus in *silver* we have the maximum polarizing angle as follows:—

		Corresponding Index of Refraction.
For red light	75½	3·866
For yellow light	73	3·271
For blue light	70½	2·824

Hence it is obvious, that at the point of restoration, where the *blue* rays are restored and vanish, the *red* rays are not restored, and consequently will appear when the principal section of the analyzing rhomb is in the plane of reflection. Here, then, we have the cause of the phenomena of the complementary colours seen in reflection from metals. They are analogous to the colours in *oil of cassia* and *chromate of lead* at the maximum polarizing angle.[1]

But the remarkable result of the preceding measures is, that in *metallic* as well as in *total reflection* the *index of refraction is less for blue than for red light*; or, in the language of the undulatory theory, the refractive index increases with the length of the wave. In a communication to the Royal Irish Academy,[2] on the propagation of light in uncrystallized media, Dr Lloyd has obtained an expression for the velocity of the propagation of light, each of its terms consisting of two parts with opposite signs, one of which is due to the action of ether and the other to that of the body. Conceiving, therefore, that there may be bodies in which the principal term is nothing, the principal part of the expression will be that derived from the second term; and if that term be taken as an approximate value, it will follow that the refractive index of the substance must be in the subduplicate ratio of the length of the wave nearly. "Now," says Dr Lloyd, "it is remarkable that this law of dispersion, so unlike anything observed in transparent media, agrees pretty nearly with the results obtained by Sir David Brewster in some of the metals. In all these bodies, the refractive index (inferred from the angle of maximum polarization) increases with the length of the wave. Its values for the *red*, *mean*, and *blue* ray in *silver* are 3·866, 3·271, 2·824, the ratios of the second and third to the first being ·85 and ·73. According to the law above given, these ratios should be ·88 and ·79."

Professor Maccullagh has[3] endeavoured to represent the phenomena described in the preceding pages by empirical formulæ, in the same manner as Fresnel represented those of total reflection. The following is a brief abstract of Professor Maccullagh's researches, which we shall give in his own words:—

"The author observes that the theory of the action of metals upon light is among the *desiderata* of physical optics, whatever information we possess upon this subject being derived from the experiments of Sir David Brewster. But, in the absence of a real theory, it is important that we should be able to represent the phenomena by means of empirical formulæ; and accordingly the author has endeavoured to obtain such formulæ by a method analogous to that which Fresnel employed in the case of total reflection at the surface of a rarer medium, and which, as is well known, depends on a peculiar interpretation of the sign $\sqrt{-1}$. For the case of metallic reflection the author assumes that the velocity of propagation in the metal, or the reciprocal of the refractive index, is of the form

$$m\,(\cos\chi+\sqrt{-1}\,\sin\chi);$$

without attaching to this form any physical signification, but using it rather as a means of introducing two constants (for there must be two constants, m and χ, for each metal) into Fresnel's formulæ for ordinary reflection, which contain only one constant,—namely, the refractive index.

"Then if i be the angle of incidence on the metal, and i' the angle of refraction, we have

$$\sin i' = m\,(\cos\chi+\sqrt{-1}\,\sin\chi)\,\sin i, \quad . \quad (1)$$

and therefore we may put

$$\cos i' = m'\,(\cos\chi'-\sqrt{-1}\,\sin\chi')\,\cos i, \quad . \quad (2)$$

if $$m'^4\cos^4 i = 1-2m^2\cos 2\chi\sin^2 i+m^4\sin^4 i, \quad . \quad (3)$$

and $$\tan 2\chi' = \frac{m^2\sin 2\chi\,\sin^2 i}{1-m^2\cos 2\chi\,\sin^2 i}. \quad . \quad (4)$$

"Now, first, if the incident light be polarized in the plane

[1] For a full analysis of these phenomena, see *Phil. Trans.* for 1830, p. 319.

[2] Jan. 9, 1837.

[3] *Proceedings of Royal Irish Academy*, Oct. 24, 1836.

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of reflection, and if the preceding values of sin i', cos i' be substituted in Fresnel's expression

$$\frac{\sin(i-i')}{\sin(i+i')},$$

for the amplitude of the reflected vibration, the result may be reduced to the form

$$a(\cos\delta - \sqrt{-1}\sin\delta), \quad . \quad . \quad . \quad . \quad (5)$$

if we put

$$\tan\psi = \frac{m}{m'}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

$$\tan\delta = \tan 2\psi \sin(\chi+\chi') \quad . \quad . \quad . \quad . \quad (7)$$

$$a^2 = \frac{1-\sin 2\psi\cos(\chi+\chi')}{1+\sin 2\psi\cos(\chi+\chi')}. \quad . \quad . \quad . \quad (8)$$

Then, according to the interpretation before alluded to, of $\sqrt{-1}$, the angle δ will denote the *change of phase*, or the retardation of the reflected light; and a will be the amplitude of the reflected vibration, that of the incident vibration being unity. The values of m', χ', for any angle of incidence, are found by formulæ (3), (4)—the quantities m, χ, being given for each metal. The angle χ' is very small, and may in general be neglected.

"Secondly, when the incident light is polarized perpendicularly to the plane of reflection, the expression

$$\frac{\tan(i-i')}{\tan(i+i)}$$

treated in the same manner, will become

$$a'(\cos\delta' - \sqrt{-1}\sin\delta') \quad . \quad . \quad . \quad . \quad (9)$$

if we make

$$\tan\psi' = mm', \quad . \quad . \quad . \quad . \quad . \quad (10)$$

$$\tan\delta' = \tan 2\psi' \sin(\chi-\chi'), \quad . \quad . \quad (11)$$

$$a'^2 = \frac{1-\sin 2\psi'\cos(\chi-\chi')}{1+\sin 2\psi'\cos(\chi-\chi')}; \quad . \quad . \quad (12)$$

and here, as before, δ' will be the retardation of the reflecting light, and a' the amplitude of its vibration.

"The number $\text{M} = \frac{1}{m}$ may be called the *modulus*, and the angle χ the *characteristic* of the metal. The modulus is something less than the tangent of the angle which Sir David Brewster has called the *maximum polarizing angle*. After two reflections at this angle, a ray originally polarized in a plane inclined 45° to that of reflection will again be plane-polarized in a plane inclined at a certain angle ϕ (which is 17° for steel) to the plane of reflection; and we must have

$$\tan\phi = \frac{a'^2}{a^2}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

Also, at the maximum polarizing angle we must have

$$\delta' - \delta = 90°. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

And these two conditions will enable us to determine the constants M and χ for any metal, when we know its maximum polarizing angle, and the value of ϕ; both of which have been found for a great number of metals by Sir David Brewster. The following table is computed for steel, taking $\text{M} = 3\frac{1}{4}$, $\chi = 54°$:—

	δ	δ'	a^2	a'^2	$\frac{1}{2}(a^2+a'^2)$
0°	27°	27°	·526	·526	·526
30	23	31	·575	·475	·525
45	19	38	·638	·407	·522
60	13	54	·729	·308	·518
75	7	98	·850	·240	·545
85	2	152	·947	·491	·719
90	0	180	1·	1·	1·

The most remarkable thing in this table is the last column, which gives the intensity of the light reflected when common light is incident. The intensity *decreases* very slowly up to a large angle of incidence (less than 75°), and then increases up to 90°, where there is total reflection. This singular fact, that the intensity decreases with the obliquity of incidence, was discovered by Mr Potter,[1] whose experiments extend as far as an incidence of 70°. Whether the subsequent increase which appears from the table indicates a real phenomenon, or arises from an error in the empirical formulæ, cannot be determined without more experiments. It should be observed, however, that in these very oblique incidences Fresnel's formulæ for transparent media do not represent the actual phenomena for such media, a great quantity of the light being stopped, when the formulæ give a reflection very nearly total.

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"The value of $\delta' - \delta$, or the difference of phase, increases from 0° to 180°. When a plane-polarized ray is twice reflected from a metal, it will still be plane-polarized if the sum of the values of $\delta' - \delta$ for the two angles of incidence be equal to 180°.

"It appears from the formulæ, that when the characteristic χ is very small, the value of δ' will continue very small up to the neighbourhood of the polarizing angle. It will pass through 90° when $mm' = 1$; after which the change will be very rapid, and the value of δ' will soon rise to nearly 180°. This is exactly the phenomenon which Mr Airy observed in the diamond.

"Another set of phenomena to which the author has applied his formulæ are those of the coloured rings formed between a glass lens and a metallic reflector; and he has thus been enabled to account for the singular appearances described by M. Arago in the *Memoires d'Arcueil*, tom. 3, particularly the succession of changes which are observed when common light is incident, the intrusion of a new ring, &c. But there is one curious appearance which he does not find described by any former author. It is this: Through the last twenty or thirty degrees of incidence the first dark ring, surrounding the central spot, which is comparatively bright, remains constantly of the same magnitude, although the other rings, like Newton's rings formed between two glass lenses, dilate greatly with the obliquity of incidence. This appearance was observed at the same time by Dr Lloyd. The explanation is easy. It depends simply on this circumstance (which is evident from the table), that the angle $180° - \delta'$, at these oblique incidences, is nearly proportional to cos i.

"As to the index of refraction in metals, the author conjectures that it is equal to $\frac{\text{M}}{\cos\chi}$."

Sect. III.—On the Colours of Metals.

Colours of metals.

In the year 1817 M. Benedict Prevost made a series of interesting experiments on the colours produced in metals by successive reflections of white light between two parallel plates. He found that the colours became brighter and deeper with the number of reflections. After ten reflections silver assumed a tint analogous to that of bronze, gold and copper became of a fine purple colour, and, in general, all the metals experienced analogous changes.[2]

In the experiments of Sir David Brewster, already described, the same phenomena were seen in the different metals which he employed; but no attempt was made to employ their results in explaining the colours of metals. It was left to M. Jamin to do this both by theory and experiment, and the methods by which he made this fine discovery are given in his paper published in the *Mémoires des Savans Etrangers* for 1847.

Theory of Cauchy.

In his beautiful theory on elliptical polarization, founded on the experiments already detailed, M. Cauchy represented the phenomena by very complicated formulæ, of

[1] See *Edin. Jour. of Science*, N.S., Oct. 1830, vol. iii., p. 278.

[2] *Ann. de Chimie*, &c., tom. iv., pp. 192-201, and 436-443.

Elliptical Polarization.

which the following are the principal results, as enumerated by M. Jamin :—

1. At very oblique incidences, all well-polished metals are absolutely white.

2. When illuminated by polarized light in the plane of incidence, they have a very pale tint of their own colour, marked by a large proportion of white light.

3. When illuminated by light polarized perpendicular to the plane of incidence, their tint is brighter, and less mixed with white.

4. At a perpendicular incidence, the proper colour of the metal, without being changed in its nature, does not vary with the azimuth of the incident ray.

The formulæ of Cauchy are founded on two data obtained from Sir David Brewster's experiments:—1. The angles of incidence at which a completely polarized ray is restored to its polarized state after two reflections between two parallel metallic mirrors. 2. The azimuth of this polarized light when that of the incident ray is 45°. In silver, for example, Sir David Brewster found that when the angle of incidence was 73°, and the azimuth of the polarized pencil 45°, the angle of restoration was 39° 48′, having experienced a rotation of $45° - 39° 48' = 5° 12'$. Other metals give different degrees of rotation. Platina, for example, is $45° - 22° = 23°$.

As the two data above mentioned vary with the refrangibility of the rays, the reflected light must generally be coloured. M. Jamin has therefore calculated the intensity of each reflected colour, and determined the colour arising from their combination by the method of Biot.[1] The results are given in the following tables :—

One Reflection.

	D			Q
Copper	69°	56′	Orange, very red	0·113
Brass	103	13	Yellow	0·112
Bell metal	83	10	Orange-yellow	0·065
Speculum metal	67	25	Orange, very red	0·027
Zinc	180	67	Blue	0·021
Silver	89	0	Orange-yellow	0·013
Steel	...		White	0·000

Ten Reflections.

	D			Q
Copper	42°	29′	Red, average	0·812
Brass	62	50	Orange, very red	0·349
Bell metal	40	40	Red	0·767
Speculum metal	53	59	Red orange	0·291
Zinc	267	58	Blue indigo	0·188
Silver	84	32	Orange-yellow	0·124
Steel	...		White	0·000

In these tables, D represents the angular distance in Newton's circular spectrum from the extremity of the red space of the calculated tint, and Q the quantity of coloured light in the reflected pencil, which is 1; the quantity of white light being $1 - Q$.

In these researches M. Jamin was led to the following laws, some of which, as will be seen from the preceding article, were long before discovered by Sir David Brewster :—

1. That the angles of restoration diminish from the red to the violet.

2. That the azimuth of restoration in some metals increase from the red to the violet, while in others they diminish.

3. In speculum metal the azimuths diminish from the *red* to the *green* rays, and increase from the *green* to the violet.

4. That all the metals of the first class have necessarily the less refrangible colour, always becoming *red* after numerous reflections.

5. That all those of the second class, though most frequently white, may have any colour in the spectrum. Explanation of Natural Phenomena

6. In several metals the observed and the calculated tints are the same.[2]

In concluding our account of the phenomena of Physical Optics, we could have wished to have given a popular account of the undulatory theory of light, and of the explanation which it affords of a great variety of the most interesting phenomena in Optics. This, however, has been done to such an extent by Dr Thomas Young, in the article CHROMATICS in this work, and in the article POLARIZATION by M. Arago, that we would not be justified in entering again upon the subject. (See Professor Forbes's PRELIMINARY DISSERTATION, chap. v.) Undulatory theory.

PART VIII.—ON THE APPLICATION OF OPTICS TO THE EXPLANATION OF NATURAL PHENOMENA.

As several of the subjects which belong to this branch of Optics have been treated pretty fully in other parts of this work, we must confine our attention to topics which have not been previously discussed.

Sect. I.—ON THE RAINBOW.

Rainbow.

A general description of the rainbow has already been given among the optical phenomena in METEOROLOGY. In order to explain the progress of the rays of light which form the two bows, let R, R, R, R (fig. 267), be parallel rays proceeding from the sun, situated at the back of the

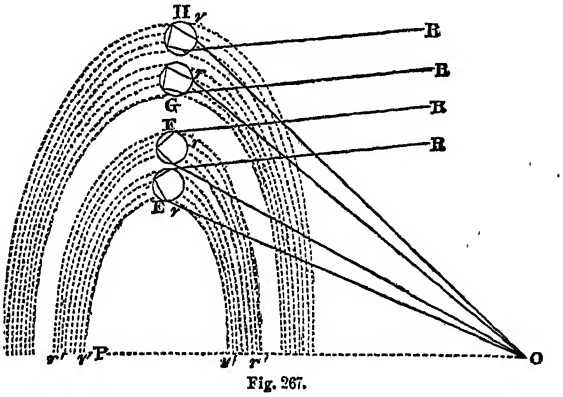

Fig. 267.

observer, placed at O, and let them fall on drops of rain E, F, G, H, in front of the observer. Some of these rays of light will enter the spherical drops of rain, and those which fall perpendicularly, and nearly so, will be transmitted through the drop, and of course never reach the observer at O. Other rays, however, especially those which fall obliquely, will be separated into the prismatic colours at the first refraction, and will subsequently be reflected *once*, *twice*, and more times, within the drop, and emerge after *one*, *two*, or more reflections in different directions. Now, it is obvious that there will be some position of the drops, such as E, F, at which rays that have suffered *one* reflection will reach the eye of the observer at O. Drops above these will throw the rays which they refract after one reflection above O, and drops below these will throw the same rays below O. In like manner, there must be some position, as at H and G, at which other drops in which the light that has suffered two reflections will fall upon the eye at O; the drops above these throwing the rays above, and the drops below them throwing the rays below O. Now, each drop forms by refraction a prismatic spectrum, or coloured

[1] *Traité de Physique*, tom. iii., p. 445.

[2] See *Comptes Rendus*, tom. xxv., p. 714; Moigno's *Repertoire d'Optique*, tom. iv., pp. 1397–1437; *Phil. Trans.* 1830, p. 319.

Explanation of Natural Phenomena

and elongated image of the sun. The rays RE, RF, which reach the eye at O, must fall upon the lower drops E, F on their upper side, as shown in the figure, and consequently (as may be found by tracing the rays through the drops) the spectrum which they form will have the *red* rays uppermost, as at *r*, near F, and the *violet* rays downwards, as at *v*, near E; and as the same effect will be produced from all the other drops which reflect the sun's rays to the point O, there will appear to an eye at O a coloured bow, such as we see it in the heavens, with all the colours of the spectrum, as if they had been formed from the sun's image by a prism of water that produced the same degree of refraction. In like manner, the rays that enter the lower side of the drops will form an inverted spectrum, after two reflections, in which the *red* rays are below, and the *violet* ones above; and as this spectrum is much fainter, it will give a second coloured bow, fainter than the first, and having its red side below, and its violet side above. The following are the dimensions of the two bows:—

Radius of the *red* edge of the *inner* bow	42°	2′
Radius of the *violet* edge	40	17
Breadth of the inner bow	1	45
Radius of the *violet* edge of the *outer* bow	54	7
Radius of the *red*	50	57
Breadth of the outer bow	3	10
Distance between the bows	8	55

Dr Halley has shown that the solar rays which suffer three reflections will form a bow round the sun at the distance of 40° 28′, and that those which suffer *four* reflections will form a bow at the distance of 45° 33′ from the sun; but the light which reaches the eye after so many reflections is too faint to be seen, and these bows have consequently never been discovered.

Supernumerary *bows* of red and green light, to the number of *three*, have been seen in contact with the violet arch of the inner bow, and we have seen them also on the outside of the outer or secondary bow. The cause of these is not known, but a very ingenious explanation of them has been given in CHROMATICS, vol. xi., p. 634, sect. iii.

Polarization of the rainbow.

Sir David Brewster, upon examining the two rainbows with a rhomb of Iceland spar, found that they consisted wholly of *light polarized* in the plane of reflection within the drop, or in planes coincident with the radii of the bow. The two bows present a case of *conical polarization*, the part of the bow vanishing as the principal section of the rhomb becomes parallel to its radius. It is strange that the polarization of the bow, and consequently of light, had not been discovered when it happened to be seen by reflection on panes of glass, or other reflecting substances, lying with their planes of reflection perpendicular to the planes of refraction within the drop, and near the angle of maximum polarization. The polarization of the rainbow was observed also by M. Biot.

Sect. II.—On Halos and Parhelia.

Halos and parhelia.

The name of halos and parhelia have been given to circles round the sun and moon, some of which are extremely complicated and beautiful. The general theory of this class of phenomena has been given by Dr Young in the article CHROMATICS, sect. ii.; and a description of the phenomena themselves, in the article METEOROLOGY, by Sir John Herschel, vol. xiv., pars. 227–232.

Artificial halos.

The production of halos, which have their origin in the refraction and reflection of light by crystals of ice floating in the atmosphere, may be illustrated by the following method given by Sir David Brewster. A few drops of a saturated solution of alum, spread over a plate of glass so as to crystallize rapidly, will cover the glass with an imperfect crust, which is composed, when examined by the microscope, of flat octahedral crystals, scarcely visible to the eye. If the observer places his eye behind this plate, and close to its smooth side, he will see the sun or the candle encircled with three fine halos placed at different distances. The interior one, which is the whitest, is formed by the refraction of the rays through two of the faces that have the least inclination to each other, and consequently give a spectrum in which the colours are not greatly dispersed; and as a similar pair of refracting planes lie in every direction, there will be a spectrum in every direction, and consequently a rainbow of a circular form. The second halo, which is *blue* without and *red* within, with all the intermediate prismatic colours more highly dispersed, is formed by a pair of faces more inclined. The third halo, which is larger and more brilliantly coloured, is produced by a third pair of refracting planes having a greater refracting power, and consequently giving a higher dispersion. When the granular crystals have double refraction, and when they crystallize with their axes perpendicular to the plates, combinations of greater variety and beauty will be produced.

Explanation of Natural Phenomena

Optical meteorology.

The phenomena presented by halos have been recently studied with much attention as a branch of what has been called *optical meteorology*. It has now been placed beyond a doubt that ice belongs to the rhombohedral system of crystals, and crystallizes in six-sided prisms with angles of 60°; and as such crystals actually float in the atmosphere, the form and the luminous condition of halos can be calculated and ascertained with as much exactness as other optical phenomena.

In an able and elaborate work on halos, published about ten years ago, M. Bravais[1] has treated the subject in the most satisfactory manner. Two remarkable halos have attracted the notice of observers,—viz., the halo of 22° and the halo of 46°. The first of these is produced by the refraction of the incident rays by the angles of 60° of the prisms of ice, and the second by the refraction of the twelve dihedral angles of 90°, formed by the six faces of the prisms with their two bases or summits. In order to compare this theory with observation, M. Bravais obtained the following indices of refraction for the different colours of the spectrum:—

	Index of Refraction.		Index of Refraction.
Extreme red	1·3043	Limit of green and yellow	1·3100
Limit of orange and red	1·3078	Limit of blue and green	1·3133
Limit of yellow and orange	1·3088	Limit of violet and blue	1·3162

With these measures he obtained the following magnitudes of the different rings of the halos:—

Halo of 22° Radius.

	Radius of Ring.		Radius of Ring.
Red ring	21° 37′	Yellow ring	21° 48′
Orange do.	21 43	Green do.	21 57

Halo of 46° Radius.

	Radius of Ring.		Radius of Ring.
Red ring	45° 6′	Green ring	46° 3′
Orange do.	45 25	Blue do.	46 50
Yellow do.	45 38		

The following explanation of the different parts of the meteor has been given by M. Bravais:—

1. The halo of 22° is produced by the dihedral angles of 60° of prisms of ice that have no particular mode of orientation.

2. The parhelion of 22° is produced by the same angles when the axes of the prisms become vertical.

[1] *Mémoire sur les Halos*, Paris, 1847, pp. 266, 4to; see also Moigno's *Repertoire*, &c., tom. iv., 1627–1638.

Explanation of Natural Phenomena

3. The circumzenithal or upper tangential arc of the halo of 46° is produced by the angles of 90° when the prisms are vertical.

4. When the axes take indeterminate directions they form across the same angles the halo of 46°.

5. The upper and lower tangential arcs of the halo of 22° are produced by the angles of 60° when the axes of the prisms are horizontal. When the sun is from 35° to 40° high, these arcs form an elliptical halo with its large axis horizontal, circumscribing the halo of 22°.

6. The parhelic circle, a white horizontal belt, sometimes incomplete, passing through the sun, is produced by reflection from the vertical faces of the prism whose axes are vertical or horizontal.

7. The extraordinary halos (extraordinary circumzenithal arcs) are produced by the faces of the pyramids, either truncated or complete, which terminate the prism.

8. The parhelia on the parhelic circles at different distances from the sun, are produced by compound crystals (asterial hexagons) of ice or snow, or by asterial dodecagons of different kinds.

9. The vertical luminous columns which appear above the rising sun are produced by internal reflections from the base or summit of the prisms when vertical, these prisms oscillating slightly round the vertical. The lustre and length of the columns are increased by 3, 5, and 7 reflections, while 2, 4, and 6 reflections produce masses of light accompanying the sun from 20° to 30° of altitude. A luminous cross is produced when these masses of light are combined with portions of the parhelic circle.

The false suns which have been so frequently observed, and the anthelia and other phenomena, may be explained by means of crystals of ice more or less perfect.

M. Bravais has not made any reference to the possible production of luminous appearances round the sun by the internal condition of the crystals of ice. We have found in pieces of ice crystalline cavities, sometimes empty and sometimes filled with water, which, like the tubes in certain specimens of Iceland spar, may produce optical phenomena; and it is quite possible that the surfaces of the crystals may not only be striated, as M. Bravais supposes, but may be disintegrated, and produce surfaces such as those described in the following section.

In order to reproduce halos and other optical phenomena artificially, M. Bravais constructed an apparatus, which is shown in fig. 268, where P is an equilateral hollow glass prism, with angles of 60°. It is filled with water by an orifice O in its tubular axis, and is made to revolve by a piece of clock-work round a vertical axis A. When it is made to revolve a hundred times in a second, and is illuminated by the sun, or by a lamp at proper distances, it will reproduce a large number of the phenomena already described.

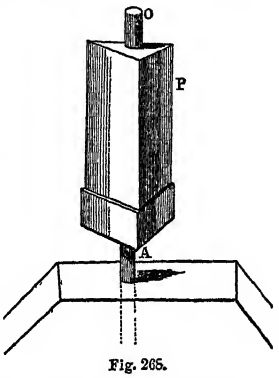

Fig. 265.

Polarization of the light of halos.

The nature and origin of halos is indicated by the state of the light of which they are formed. We owe to M. Arago the important observation that the light of halos is polarized by refraction.[1]

The following observations were made by M. Bravais:—

1. The parhelic circle consists of a circle formed by external reflection superposed upon a circle formed by internal reflection.

The first of these is polarized in a plane passing through the luminous source—that is, horizontally or negatively. It is a maximum towards 70°, the polarization disappearing at 0° and 180°.

Explanation of Natural Phenomena

In the second circle no polarization is seen in the part of the circle produced by total reflection, but it is very strong and horizontal or negative in the part formed by partial reflection, the maximum being at and beyond 30°. Hence, when the two circles form the parhelic circle, there should be a maximum at 75°, and another towards 100° or 120°.

2. The halo of 22° is feebly polarized by refraction, the opposite polarization of the atmosphere by reflection reducing it considerably.

3. The tangent arcs of the halos of 22° and 46° ought to be polarized tangentially.

4. The parhelion of 46° ought to be polarized vertically.

5. The polarization of the anthelia ought to be horizontal and strong.

6. The luminous columns ought to be polarized vertically, and strongly at their extremities.

These theoretical results, and others, have been confirmed by experiments with the apparatus above described, but, with the exception of M. Arago's observations on the actual polarization of halos, the condition of the light of real halos remains to be investigated. M. Bravais, however, has made new observations on the halo of 22°. The tangential polarization is always strong at its upper and lower points, and it extends 5° or 6° beyond the halo, there being a neutral ring at 27°, beyond which the polarization is normal. The polarization within the halo suffers remarkable changes. M. Bravais found it nothing in the upper part on the 4th October 1847; horizontal in its lateral parts on the 8th September, and on the 5th, 10th, and 16th of October, 1847; and at other times vertical. These remarkable changes arise from extensive changes in the polarization of the atmosphere.[2]

Converging beams.

Among the phenomena of optical meteorology may be ranked those of *diverging* and *converging* beams. The phenomenon of diverging beams is so common in summer, when the sun is near the horizon, and its cause so obvious, that it is unnecessary to say more about it than that it arises from portions of the sun's rays passing through openings in the atmosphere, the adjacent portions being stopped by clouds. The phenomenon of *converging* beams is of rare occurrence. It is seen in the horizon *opposite* to the sun, and the beams converge to a point as far beneath the horizon as the sun is above it; so that they appear to diverge as it were from another sun placed in the antesolar point. Sometimes the beams appear to be black, the dark spaces between the luminous radiations appearing the more distinct of the two. The phenomenon is one of perspective. If the N. pole of a terrestrial globe is placed 10° above the horizon, and is supposed to send out radiations in the plane of each of its 15 meridians, they will all meet or converge to its south pole, 10° below the horizon.[3]

Luminous circles in Iceland spar.

As explanatory of phenomena yet unexplained, or which may yet be discovered in optical meteorology, we may describe the very curious luminous circles produced by looking at the sun or a candle through certain specimens of Iceland spar. In one position of the rhomb the two rings or circular bands A, B (fig. 269), are equal, passing through their point of contact S, which consists of the two superposed images produced by double refraction. Upon inclining the rhomb, the circle A becomes less and less, while B becomes larger and larger, till A

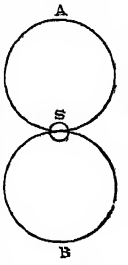

Fig. 269.

[1] M. Bravais calls this *tangential* polarization, in opposition to normal, or polarization by reflection.

[2] Brewster's *Treatise on Optics*, p. 394.

[3] See *Edin. Jour. of Science*, April 1832, vol. vi., pp. 25, 256.

Explanation of Natural Phenomena

disappears in S. Continuing the inclination in the same direction, A reappears within the ring B, but always touching S, and becomes larger and larger along with B till the two almost form a straight line, and bend in the opposite direction. The two rings are the two images formed by double refraction, and are oppositely polarized. They are produced by reflection from the cylindrical surfaces of minute tubes in the mineral, of which there are several thousands in an inch. We have found similar rings in beryl. The two are oppositely polarized, and are produced by the cylindrical surfaces of tubular cavities which contain, or have contained, the two new fluids called by Dana Brewstoline and Amethystoline, found in topaz, amethyst, and other minerals.[1]

Circular crystals.

As compound crystals of snow, called lateral,[2] are supposed by M. Bravais to produce some of the luminous portions of halos, there may be other crystalline groups in the air formed of other substances than water, which may produce luminous phenomena. The subject of circular crystals, therefore, becomes an interesting branch of optical meteorology; and when we consider how many substances exist in the air in a state of minute subdivision, and may therefore combine in single crystals, as well as in crystalline groups, it is hardly philosophical to assume that the various complex phenomena produced by the sun's light are owing *solely* to crystals of ice and snow. The most beautiful halos may be produced by various bodies, whose separate crystalline particles arrange themselves in radial lines round a centre, and these halos are sometimes polarized tangentially or by refraction, like those in the atmosphere. These halos are finely seen in oil of mace, properly melted and cooled between plates of glass. Our limits will not permit us to treat of this subject. It may be sufficient to state that Sir David Brewster has given a list of *seventy* circular crystals, about thirty of which are positive, and forty negative.[3]

We have endeavoured, by looking through hoar-frost upon glass, to produce halos actually resembling those seen in nature; but we have not succeeded, though we have no doubt that it may be effected by causing vapour deposited under a variety of circumstances to be frozen in different ways.

Sect. III.—On the Figures produced by Reflection from Disintegrated Surfaces.

Reflection from disintegrated surfaces.

The remarkable forms produced by the light of the sun and moon by the action of crystals floating in the atmosphere may be illustrated by the figures produced by reflecting or transmitting solar or artificial light from or through the surfaces of crystals upon which various facets have been developed by different solvents.

If we reflect the light of a candle from a fine surface of *alum* ABC, we shall see an image of it at S. If we dip the surface in *water*, and dry it quickly, we shall see three luminous radiations *m*, *n*, *o* proceeding, as it were, from A, B, C. A second immersion will develop other three at 1, 2, 3; a third will join 1, 2, 3 with S; and a continued action will produce other three at 4, 5, 6, then at 7, 8, 9. The central image S will finally disappear, the whole of the original surface of the crystal which reflects it having been removed, and numerous facets variously inclined to it developed.

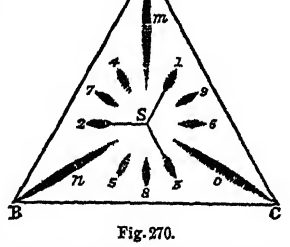

Fig. 270.

Explanation of Natural Phenomena

By dipping the surface thus disintegrated into a saturated solution of alum, particles of alum will replace those which were removed, till, by repeated immersions, the surface ABC will become a perfect surface, reflecting, as it did at first, a bright image of the candle,—the particles of alum flying into their proper places with inconceivable rapidity.

An octahedral face of *fluor spar*, acted upon for a few days by *sulphuric acid*, will display the remarkable figure shown in fig. 271, the parts of which are developed in the following order:—A, B, C, *mno*, *ef*, *gh*, *ik*; then six curves proceeding from the image *ef*, *gh*, *ik*, as in fig. 272, and having a new round image within their concavity. Three insulated images appear also at *l*, *m*, *n*, 120° distant. The figure *ab*, *ac*, *bc* was observed on a natural cleavage surface of fluor spar; and the same was produced upon another cleavage surface by grinding it upon a rough hone. The figure *ab*, *ac*, *bc* is sometimes seen along with the new figure, as in fig. 272.

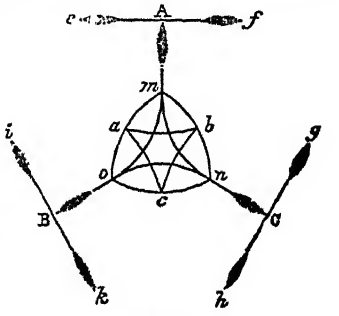

Fig. 271.

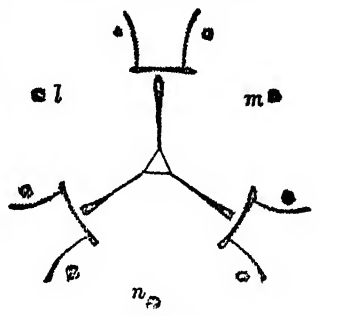

Fig. 272.

Different figures are produced on the faces of the cube, and singular varieties may be developed by increasing the strength of the acid and the duration of its action.

Figures analogous to those described may be seen on the natural cleavage planes of various crystals, such as *Brazil, topaz, fluor spar, hornblende, axinite, boracite, diamond, garnet, amethyst, oligist iron ore, muriate of soda*, &c. One of the most curious of these figures is shown in fig. 273. It has been produced by the action of some natural solvent upon the summit or principal cleavage plane of *Brazil topaz*.

Fig. 273.

Analogous phenomena may be readily produced by the mechanical abrasion of coarse sandstone, or of a rasp or large-toothed file. In these cases the figure had a different position from those produced by solvents, or had the position which a solvent would have produced on the opposite side of the crystal.

The superficial structures above described may be communicated to wax, isinglass, gum, fusible metals, &c. Those on isinglass again enable us to observe better by transmitted light the forms and dimensions of the figures.

The phenomena described in the above section were described by Sir David Brewster in the *Edinburgh Transactions* for 1837, vol. xiv., p. 164; and reprinted in the *Phil. Mag.*, Jan. 1853, p. 16, illustrated by *thirty-three* figures. The experiments, we believe, have never been repeated, and hardly noticed by writers on optics.

[1] See *Phil. Mag.* 1848, vol. xxxiii., p. 489.
[2] Mr Glaisher has published an immense number of drawings of these singularly beautiful crystals.
[3] See *Phil. Trans.* 1815, and *Edin. Trans.* 1853, vol. xx., p. 607.

Explanation of Natural Phenomena

Unusual refraction.

Sect. IV.—On the Unusual Refraction and Reflection of the Atmosphere.

One of the most interesting applications of optical science is the explanation which it affords of the extraordinary phenomena which arise from difference of density in different parts of the atmosphere. On this subject we shall confine ourselves at present to an account of the most extraordinary of all the phenomena of this kind which have been observed and correctly described. It was observed by Dr Vince, on the 6th of August 1806, about seven o'clock in the evening. Between Ramsgate and Dover there is a hill, over which the tops of the four turrets of Dover Castle are usually seen to a person at Ramsgate. At the time above mentioned, however, Dr Vince, when at Ramsgate, not only saw the four turrets *v*, *x*, *w*, *y*, but the whole of the castle, *m*, *n*, *s*, *r*, appearing as if it were situated on the side of the hill next to Ramsgate, and rising as much above the hill AB as usual, as if it had been brought over and placed on the Ramsgate side of the hill (fig. 274). This appear-

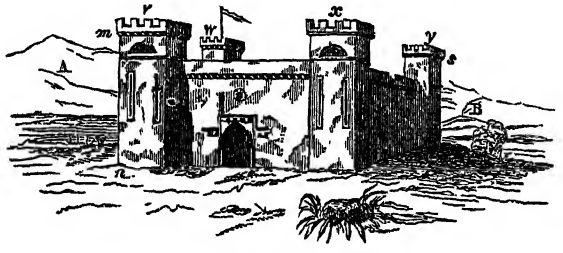

Fig. 274.

ance continued about twenty minutes. Between Ramsgate and the land from which the hill rises there is about six miles of sea, and from thence to the top of the hill about the same distance, the height of the eye above the surface of the sea being about 70 feet. It is a very singular circumstance in this phenomenon, that the image of the castle was so very strong and well defined that the hill itself did not appear through the image.

In order to explain this phenomenon, Dr Vince supposes AB (fig. 275) to represent the castle, FC the cliff of

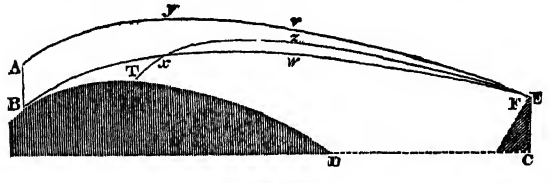

Fig. 275.

Ramsgate, BTD the hill, DC the sea, E the place of the spectator, T the top of the hill, A*yv*E a ray of light coming from the top of the castle to the observer, and B*xw*E another ray coming from the bottom of the castle, and T*xz*E a ray from the summit of the hill, reaching the eye at E, in a direction between those of the other two rays; then it is obvious that such a disposition of the rays will produce the observed appearance. In order to give such a refraction, the density of the air between *yv*E and *xw*E must have varied with great rapidity, so as to increase the curvature of the ray T*xz*E, after it cuts B*w*E in *x*, in order to make the ray T*xz*E fall between the other two rays. (See *Edinburgh Transactions*, vol vi., p. 245.)

Some of the cases of mirage ascribed to unusual refraction have been produced by reflection from dense mist or fog in the atmosphere. Dr Buchan has described, in the *Philosophical Transactions*, a remarkable case of this kind; and another of peculiar interest was observed in Radnorshire on the 21st August 1851. A young lady, having left her party, ascended to the top of the Mynydot, a steep hill about 500 feet above the valley of New Radnor. About two o'clock, when the sun was bright and the day sultry, she picked some wild flowers on the top of the hill, and then descended to a spot from which she could see the carriage with her friends whom she had left. After waving her victorine, which she held in her hand, to her friends, she perceived, upon turning round, a figure standing a few yards from her upon a wet spot, *from which a little thin mist was rising.* The figure stood directly opposite to her, wavering a little; and she did not recognise it to be her own image till she noticed that, like herself, it held a victorine and a bunch of flowers in its hand. The dress of the figure resembled her own, and the flowers were similar to those which she had gathered; and the picture was so distinct that she could even see her own face. The effect, she said, was the same as if she had stood before a looking-glass, the figure moving its hand when she moved hers. The two ladies in the carriage at the bottom of the hill saw the image of the lady; and they asked her, when she joined them, who was her companion on the hill!

Explanation of Natural Phenomena

In the ordinary cases of mirage from unusual refraction, the refracted image is seen above the real one, either inverted or erect, or both; but cases of *lateral mirage* have occurred, in which the image is on the right or left side of the object. When any part of the ground has been heated by the sun, it forms in the atmosphere, on cooling, a column of heated air, which produces the phenomena of unusual refraction at its junction with the colder air around it. From this cause, ships on the Lake of Geneva have been seen doubled, and sailing at a considerable distance from each other; and persons walking have been seen in duplicate.

Lateral mirage.

Sect. V.—On the Colours of the Atmosphere.

As the earth's atmosphere acts upon light like all other transparent bodies, and is continually changing its chemical, mechanical, and hygrometrical condition, its action is magnified in very different ways under different circumstances. As the colour of the sky is absolutely black on the tops of the highest mountains, its blue colour in the regions which we inhabit is owing to the action of the atmosphere.

Colours of the atmosphere.

That the *blue* light of the sky is light that has suffered reflection from the particles of our atmosphere is proved by the fact observed by Sir David Brewster, that this blue light is polarized in a plane passing through the observer's eye and the sun. This fact is well illustrated by the discovery which we owe to the same author, of *atmospheric lines* in the spectrum formed by the blue sky. These lines are principally in the *red* or more refrangible spaces, as already described, and hence the prevailing light is blue.

The splendid colours which mark the rising and the setting of the sun, varying from the deepest *red* to *orange*, *yellow*, and even *green*, arise from the same cause; for when we analyze these various lights with the prism, we find that they are owing to different parts of the spectrum having been absorbed by the atmosphere.

The phenomenon of blue shadows is finely seen when the sky is particularly blue. It arises solely from the shadows being illuminated by the blue sky, while the part round the shadow is illuminated by the sun, or by the light of a candle. If the light of the sun passes at the time through vapours, so as to make it yellow or orange, the contrast of the shadow is still more striking and beautiful. The light of a candle which contains a great excess of red light, and which may be made to contain more by letting it burn with a long wick, exhibits along with the light of the sky the phenomenon of blue shadows in great perfection.

Blue shadows.

Much light has been thrown upon the subject of the colours of the atmosphere by Professor Forbes, in an able and interesting memoir, read to the Royal Society

Professor Forbes's experiments.

Explanation of Natural Phenomena

of Edinburgh in 1839.[1] In a previous communication he had drawn the following conclusions from a series of important experiments "On the Colour of Steam under certain circumstances:—

"1. Steam, in its purely gaseous form, is colourless,—at least at small thicknesses.

"2. The orange red colour of steam by transmitted light appears to be due to a particular stage of the condensing process. Before condensation, it is colourless and transparent; it is next transparent and smoke-coloured; finally, it becomes colourless at small thicknesses, and absolutely opaque at greater.

"3. The state of tension of the steam seems only to affect the phenomena so far as it renders the critical colorific stage of condensation more or less completely observable.

"4. The absorptive action of steam on the spectrum is not exerted in the same way as that of other gaseous coloured bodies, such as nitrous acid gas and iodine vapour. It cuts off, however, totally the same part of the spectrum as nitrous acid does. Its phenomena, perhaps, have a greater analogy to those of opalescence than any other."

As the phenomena thus described do not require steam of high tension for their production, Professor Forbes "thought it probable that the tints of sunset and artificial light seen through certain fogs may be owing to the absorptive action of watery vapour in this critical condition."[2]

This ingenious theory of atmospheric colour is ably supported in his second paper, in which Professor Forbes discusses the various opinions on the colour of the sky and of the clouds which have been hitherto maintained.

An instrument called a *Cyanometer* has been invented for measuring the blue colour of the sky.

Sect. VI.—On the Polarization of the Atmosphere.

Polarization of the atmosphere.

The polarization of the atmosphere,—that is, of the blue sky entirely free of clouds,—was observed and described by different philosophers both in France and England. Whatever reflects and refracts light necessarily polarizes it at an angle dependent on the index of refraction. Hence it follows, that the polarizing angle of air is a little above 45°; and consequently, that, in the vicinity of the sun, and in the region opposite to him, the polarization should be a *minimum*, and a *maximum* in every part of a great circle distant a little more than 90° from the sun.

Owing to the quantity of light polarized by refraction at every point where it is polarized by reflection, and to secondary reflections within the atmosphere, the polarization is never complete in the great circle of 90° from the sun. It is equal only to a rotation of 30° of the plane of polarization, or what is produced by one reflection at an angle of 65½° from a surface of glass whose index of refraction is 1·483.

Arago's neutral point.

The first important step in studying this subject was made by M. Arago, who discovered in the region opposite the sun a *neutral* point in which there was no polarization. It was situated 25° or 30° above the antisolar point, or the point 180° from the sun. Sir David Brewster found, that when the sun was in the horizon, rising or setting, this neutral point was 18½° above the antisolar point in the opposite horizon. When the sun is 11° or 12° above the horizon, and the antisolar point of course as much below it, the neutral point is in the horizon, and therefore only 11° or 12° above the antisolar point. As the sun descends to the horizon, and the antisolar point rises, the distance of the neutral point from the latter gradually increases from its *maximum* 11° or 12°, till it becomes 18½° when the sun is in the horizon, and increases to 25° when the sun is so far below the horizon as just to render the point visible. In the latitude of St Andrews this neutral point is above the horizon all the day between the middle of November and the end of January; and in the rest of the year it never rises till the sun is within 11° or 12° of the horizon, and never sets till the sun is 11° or 12° above the horizon.

Explanation of Natural Phenomena

Secondary neutral point.

On the 8th of June 1841, Sir David Brewster discovered a secondary neutral point accompanying that of Arago. It is best seen above the sea horizon. On the 21st April 1842, the secondary neutral point was 2° 50′ high when the primary neutral point was 15° above the horizon. These two neutral points were separated by negative or horizontal bands of negative polarization. When Arago's neutral point rises, *it does not first appear in the horizon*, but 1½° above it.

Babinet's neutral point.

M. Babinet discovered a *second* neutral point at 18½° above the sun when rising or setting. It is never seen so distinctly as that of Arago. When the sun is in the zenith, this neutral point coincides with the sun; and as the sun's altitude diminishes, it retires from the sun, becomes 13° distant at an altitude of 65°, and it reaches the distance of 18½° at sunrise or sunset. The secondary neutral point, which *must* accompany that of Babinet, has not yet been observed. Calling x the distance of this point above the sun, and A the sun's altitude, we have $x = 18\frac{1}{2}° \cos A$.

Brewster's neutral point.

A *third* neutral point, indicated by theory, was discovered beneath the sun by Sir David Brewster. This point is very difficult to be seen. It is invisible in our latitudes in the months of November, December, and January, unless when, early in November and late in January, a higher degree of polarization in the sky brings it above the horizon at noon. When the sun is in the zenith, it coincides with his centre; and at an altitude of 45° it is nearly 7° distant from him. The secondary neutral point which must accompany it has not yet been seen, and is not likely to be discovered in this climate. The distance x' of this neutral point below the sun will be $x = \frac{18\frac{1}{2}° \cos A}{\tan z}$, z being the zenith's distance of the neutral point.

When the sun is in the zenith, and the neutral points of Babinet and Brewster united in his centre, the system of lines of equal polarization will be analogous to those of uniaxal crystals; but in all other positions of the sun, the lines of equal polarization will resemble those in biaxal crystals, the line joining the sun and the antisolar point corresponding with the line which bisects the optical or resultant axes of biaxal crystals, the neutral points corresponding with the centres of the systems of biaxal rings.

In a normal condition of the atmosphere, the phenomena of atmospherical polarization may be represented by the formula,

$$R = 30° (\sin D \sin D'),$$

in which R is the rotation or degree of polarization at any point of the sphere whose distance from the two neutral points is D and D′.

By this formula, the lines of equal polarization would have the form of *lemniscates*, as in biaxal crystals, and the maximum polarization would be in the horizon, and not in the zenith, which is contrary to observation. By making a correction depending on the zenith distance Z and the azimuth A, the formula becomes

$$R = 33\tfrac{1}{3}° (\sin D') - 6° 34' (\sin Z \sin A).$$

A map of the lines of equal polarization will be found in Johnston's *Physical Atlas*, part vii.[3]

Sect. VII.—On the Colours of Natural Bodies.

Colours of natural bodies.

The splendid colours which appear in the natural world

[1] *Edin. Trans.*, vol. xiv., part ii., pp. 375–391; or *Phil. Mag.*, June 1839, vol. xiv., p. 419.
[2] *Phil. Mag.*, Feb. 1839, vol. xiv., pp. 121–126.
[3] See also *Phil. Mag.*, Dec. 1847, vol. xxxi., p. 444; and Moigno's *Repertoire*, &c., tom. iv., pp. 1639–1648.

Explanation of Natural Phenomena

have long attracted the attention of philosophers; but no person ever had the courage to give a philosophical theory of them but Sir Isaac Newton. When he had completed his analysis of the colours of thin plates, he conceived that they furnished the true cause of the colours of natural bodies. If we take a thin film of mica, a few millionths of an inch in thickness, it appears to the eye of a bright blue colour. Sir Isaac Newton maintained, that if this film could be cut into a great number of minute parts of the same thickness as itself, these particles would "keep their colour, and a heap of them constitute a mass or powder of the same colour which the plate exhibited before it was broken." A plate of mica of a different thickness would be *green*, another *yellow*, and another *red*; and all these, if broken down into particles "of the same thickness with the plates," would of course, according to our author, give a *green*, a *yellow*, or a *red* mass.

We have already seen that different thicknesses of a transparent plate like mica give various orders of colours, each having a different tint corresponding with a particular thickness. Considering, then, the particles of all bodies whatever as transparent, and as having different sizes, they will produce colours corresponding to these different sizes; and consequently we shall have as great a variety of tints in nature as there are varieties in the sizes of the particles of bodies. A difficulty, however, here presents itself. The colours arising from thin plates vary rapidly by inclining them to the incident light, whereas those of coloured media suffer no such change. Hence Sir Isaac Newton was driven to the supposition that the particles of bodies have such an enormous refractive power, that the paths of the rays refracted by a parallel film will not differ much in length from, and consequently not be very oblique to, a perpendicular line. After explaining this theory, Sir Isaac ventures to affix to different natural colours the order to which they belong, the very tint of that order, and consequently the thickness of the particles which produce the colour. He says, for example, that the *green* colour of all vegetables, the most general tint in nature, is a *green* of the third order, and that the *blue* colour of the sky is a *blue* of the *first* order. Now, we know the composition of a *green* of the *third* order, and of a *blue* of the *first* order, as given by Sir Isaac Newton himself. The *green* of the *third* order "is principally constituted of original *green*, but not without a mixture of some *blue* and *yellow*;" that is, it consists of all the rays of the green space, with the least refrangible rays of the *blue* space, and the most refrangible rays of the *yellow* space, and it does not contain a single ray of *indigo*, *violet*, *orange*, or *red* light.

Green colours of plants.

Such being the case, it occurred to Sir David Brewster that the green colour of plants could be accurately analyzed by the prism; and having extracted, by means of alcohol, the green juice of a great variety of vegetable bodies, he analyzed their colours by the prism. In all such bodies he found the composition of this green colour to be identically the same; but it had no relation whatever to the *green* of the *third* order. It contained portions of all the colours of the spectrum; and the prismatic spectrum seen through these green juices was divided unequally into *six* luminous bands of various breadths, separated by dark intervals.[1] In the same manner he found that the *blue* colour of the sky was not a *blue* of the *first* order.

From a series of experiments in which the same author has been engaged, he has been led to the conclusion that absorption is the cause of this extensive class of colours; and that all the colours of natural bodies arise from the interference of light, by which certain rays are extinguished. When the interference takes place as in thin plates, between the light reflected from the two surfaces, and between the direct transmitted ray and other transmitted rays which suffer reflection within the thin plates, we have two colours complementary to each other; but even in this case, when the number of films is great, as in decomposed glass, the transmitted colours lose all their resemblance to the colours of thin plates, while the reflected tints are exceedingly brilliant and metallic in their lustre.[2]

Explanation of Natural Phenomena

In coloured fluids and coloured glasses, and coloured gaseous media, the interference arises from rays that acquire different velocities in passing through the coloured medium, one part of the intromitted light passing through the particles, and the other through the intervening spaces. Hence there are no reflected tints in such coloured media.[3]

Sect. VIII.—On the Colours of Dispersed Light within Solid and Fluid Bodies.

Colours of dispersed light within solid and fluid bodies.

In various solid and fluid bodies, coloured light is reflected from their interior when a colourless beam of light is transmitted through their mass. This light is produced by different causes, often by vacuities of various forms sufficiently small to reflect the colour of thin plates, as in Labrador spar, tabasheer, opals (precious and hydrophanous), and numerous chemical solutions. The colours, however, of which we mean to treat at present are of a different description, and have a different origin.

The *internal* dispersion of light within *fluor spar* (from which this class of dispersed colours has received from Professor Stokes the name of *fluorescence*) was first observed by Sir David Brewster, who described it in 1838 to the meeting of the British Association at Newcastle.[4] The light itself had been observed by others, but it was believed to be *external*, and was ascribed by Sir John Herschel to a structure of "the surface of the spar, whether natural or artifical, which could not be removed by any polishing."[5] By examining various specimens Sir David Brewster not only found that the predominant *blue* light in the spar from Alston Moor came from the interior of the mineral, but that different strata dispersed light of different colours,—*blue* light from some strata, *pink* from others, and *white* from others, alternating with strata which dispersed no light at all. The same property of dispersing light of different colours he found in various coloured glasses, especially in *yellow Bohemian glass*, called canary glass, which dispersed a fine *green* colour, and in some specimens of colourless plate and colourless flint-glass. The most beautiful example of the phenomenon he found in an alcoholic solution of the green leaves of plants (the common laurel leaf, for example, cut into shreds), which dispersed from its interior a *blood-red* light. The same property he found in guiacum, and in solutions of *Colchicum autumnale*, and *sulphate of strychnine*.[6]

Chemists had long ago noticed the *blue* colour of a weak solution of *sulphate of quinine*, but Sir John Herschel[7] was the first person who examined it experimentally. He gave it the name of *epipolism*, from επιπολη, a surface, believing it to be produced solely by the action of the surface. Upon examining it with a prism, he found it to consist of a "small per centage of rays extending over a great range of refrangibility."

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[1] See *Edin. Trans.*, vol. xii.
[2] *Phil. Trans.* 1837, p. 245.
[3] See Brewster's *Memoirs of Sir Isaac Newton*, vol i., chap. viii.
[4] *Report*, &c., 1838, p. 10.
[5] *Treatise on Light*, § 1076.
[6] *Edin. Trans.* 1846, vol. xvi., p. 111.
[7] "On a case of Superficial Colour presented by a Homogeneous Liquid internally Colourless," *Phil. Trans.* 1845, part ii., p. 143; and "On the Epipolic Dispersion of Light," ibid., p. 147.

Explanation of Natural Phenomena

By transmitting a condensed beam of convergent light through a vessel containing a solution of *sulphate of quinine*, Sir David Brewster found that the reflection was not superficial but internal, as in fluor spar; and upon analysing it with a prism, he found that the *blue* light gave a continuous spectrum deprived of the *less refrangible red*, nearly of the whole *orange*, and all the *yellow*. A rich and broad band of fine green light, slightly fringed with *red*, passed into a copious *indigo* and *violet*, without the intermediate *blue*, the *green* extending over the *blue* and *yellow* spaces.[1]

In studying the nature of this *internal dispersion*, Professor Stokes of Cambridge has made the important discovery that the chemical rays in the spectrum between G and H produce in the quinine solution "light of a sky-blue colour, which emanate in all directions from the portion of the fluid which was under the influence of the incidental rays." The fixed lines in the *violet* space, and in the region of *invisible* rays beyond the violet are represented in dark lines corresponding with those on E. Becquerel's map of the fixed lines in the chemical spectrum.

Regarding this *blue* light as the invisible rays rendered visible by internal dispersion, Professor Stokes came to the conclusion that the dispersing cause had *changed the refrangibility of the exciting rays, and given them all the different colours of the spectrum.*[2]

We have already seen that E. Becquerel found that the chemical rays beyond H rendered artificial phosphorus luminous, while those from H to A extinguished the phosphorescence thus produced.

Sect. IX.—On the Eye and on Vision.

The eye and vision.

In our article on Anatomy,[3] we have already given a full description of the organ of vision, and Plate XXXIII., fig. 3, exhibits a fine section of the eye after Soemmering. The following dimensions of the eye have been given by Dr Thomas Young, the measures being taken with great care from his own eye:—

	100ths of an inch.
Length of optical axis	91
Vertical chord of the cornea	45
Versed sine of ditto	11
Horizontal chord of the cornea	49
Aperture of the pupil seen through the cornea	27 to 13
Diminished in consequence of the magnifying power of the cornea	25 to 12
Radius of the anterior surface of the crystalline lens	30
Radius of the posterior surface	22
Distance of the optical centre from the anterior surface of the lens	10
Distance of the optical centre of the lens from the cornea	22
Focal length of the cornea for objects 10 inches distant	115
Joint focus of cornea and lens 91 – 22 =	69
Principal focal distance of lens	173
Distance of the centre of the optic nerve from the point opposite the pupil	11
Range of the eye, or field of vision	110

The following measures of the crystalline lens and cornea were taken by Sir David Brewster and Dr Gordon from the eye of a female above fifty years of age, a few hours after death:—

Diameter of the crystalline	0·378
Diameter of the cornea	0·400
Thickness of the crystalline	0·172
Thickness of the cornea	0·042

The following measures of the refractive powers of the humours of the eye were taken by the same authors from the same eye:—

	Index of Refraction.
Refractive power of water	1·3358
Ditto of aqueous humour	1·3366
Ditto of vitreous humour	1·3394
Refractive power of outer coat of crystalline	1·3767
Ditto of middle coat of ditto	1·3786
Ditto of central part of ditto	1·3990
Ditto of the whole crystalline	1·3839

Explanation of Natural Phenomena

The following measures may be occasionally useful:—

	Index of Refraction.
From aqueous humour into the crystalline	1·0466
Do. do., taking the mean index of the crystalline	1·0353
From the crystalline into the vitreous humour	0·930

Vision.

If we execute a large diagram of the eye, and by means of the above indices of refraction trace the progress of parallel rays from the cornea to the retina, we shall find that they converge to points in or near to that membrane. The increase of density in the crystalline lens towards its cent e is calculated to correct the spherical aberration by bringing the central rays to the same focus with the marginal rays; but there is no provision in the eye for correcting the aberration of colour, because the purposes of vision do not require it to be corrected. It may be readily proved by tracing the rays diverging from both extremities of any object to the retina, and it may be also shown by direct experiment, that an inverted image of the object is formed upon that membrane. Now it is a law of vision, that when a ray of light falls upon any point of the retina, the mind infers that the ray proceeded from a point in some line perpendicular to that point of the retina. Hence, as rays from the upper part of an object fall upon the lower part of the retina, and *vice versa*, such rays will seem to proceed from the upper part of the object, and all points of an object will be seen in the direction of the rays which issue from them, and consequently the object itself must appear erect, though its image is inverted.

Law of vision.

Cause of erect vision.

Single vision with two eyes.

As it is a law of vision that an object seen with a single eye is seen in a fixed direction, arising from the form of the retina as a whole, or from the form of its individual parts, then if rays from the same object fall upon another eye, or upon a hundred other eyes which have the power of placing the retina of all the eyes so as to see the same object in the same direction, then the object thus seen must appear single. The only difference will be, that the object will be seen twice as bright with two eyes, and a hundred times as bright with a hundred eyes. If we place a hundred shillings in the same straight line, an eye whose axis coincides with the axis of the cylinder which they compose will only see one shilling, and the same effect would be produced if the shillings were transparent. If the hundred eyes were placed with their axes in a hundred different directions, a hundred objects will be seen. Small objects are seen double, and even triple, with one eye when the crystalline lens is not uniform in its refractive power.

The subject of binocular vision will be treated of under the article Stereoscope.

Origin of squinting.

The defect of squinting may arise from several causes. It may be an original defect, in which the axis of the eye, or the light in which objects are seen most distinctly, does not pass through the centre of the pupil. In this case it is incurable; but it is, generally speaking, a disease arising from an imperfection in one eye, from its having a different focal length from the other, from its giving a less distinct vision of objects, or from its muscles not being able to direct it as quickly as the other to visible objects. The consequence of this is, that as the observer can do without it, and uses only his best eye, the imperfect one does not follow the movements of the other, and therefore squints.

Indistinctness of oblique vision.

When we wish to see any object very distinctly, we invariably direct it to the axis of the eye, and it is a curious fact that there is no retina at the point where the axis meets the back of the eye, the *foramen centrale* corresponding to the extremity of the axis. When the eye thus sees an object

[1] *Edin. Trans.* 1846, vol. xvi., p. 111. [2] *Phil. Trans.* 1852, pp. 463–562. [3] Vol. iii., p. 43.

Explanation of Natural Phenomena

with perfect distinctness, every other point of the same object is seen indistinctly, and there is no adjustment of the eye by which distinctness of vision can be obtained at any distance from the axis of the eye, the only way of seeing distinctly being to direct the axis to the point we wish to examine.

Indistinct vision at the base of the optic nerve.

The opinion that the retina, though sensible to light, does not give perfectly distinct vision, is favoured by the fact, that when the image of any object falls upon the round base of the optic nerve (shown in Plate XXXIII., fig. 3 of ANATOMY), the object is not distinctly visible. This may be easily proved by fixing on the wall of a room, at the height of the eye, three wafers, each two feet distant. Stand in front of the middle wafer with one eye shut, and beginning near the wall, withdraw gradually from it (continuing to view the left hand wafer if the right eye is open, and the right hand wafer if the left eye is open), till the middle wafer vanishes. This will be found to take place at five times the distance from the wall at which the wafers are placed,—that is, at the distance of ten feet in the present case. If we use three candles, the middle one will not vanish like the wafer, but will become a cloudy mass of light.

Occasional insensibility of the retina in oblique vision.

The occasional insensibility of the retina to objects seen obliquely was discovered by Sir David Brewster, who has illustrated it in the following manner:—If we fix one eye on a particular point, such as the head of a pin stuck into a green cloth, and lay down a quill or strip of paper upon the green cloth, some inches distant from the pin, and then keep looking steadily at the pin's head, part of the quill, or the whole of it, will occasionally disappear, as if it had been wholly removed from the cloth. In a short time it will reappear, and again vanish. The very same effect is produced, though less readily, when both eyes are used, and when a luminous body is used in place of the quill. In this case the luminous body does not disappear, but expands into a mass of nebulous light, which is of a bluish white colour, encircled with a bright ring of yellow light.

Superior brightness of objects seen obliquely.

But though we cannot see objects distinctly by oblique vision, yet they appear much brighter, and minute objects, especially luminous ones, are more easily seen, by turning the axis of the eye away from them. Various astronomers have found that very faint stars, and the satellites of Saturn, which disappear when the eye is turned fully upon them, may be distinctly seen by directing the eye to another part of the field. This effect seems to arise from the expansion and enlargement of luminous points seen obliquely.[1]

On the seat of vision.

It has long been disputed, but the question has not been much agitated in modern times, whether the retina or the choroid coat behind it is the seat of vision. The insensibility of the base of the optic nerve, and the fact that vision is most distinct where there is no retina, are arguments in favour of the choroid coat being the seat of vision, as Mariotte believed. The transparency of the retina, and the opacity of the choroid coat, were considered as additional arguments in favour of that opinion. Dr Knox has shown that in the eye of the cuttle-fish there is a membranous opaque pigment in front of the retina; so that in this case the retina must receive the influence of light from the vibrations of this membrane, just as it may receive them in other cases from the same membrane placed behind it.

Some light has been recently thrown upon this subject by an experiment which we owe to Sir David Brewster, in which the foramen in the retina can be rendered distinctly visible. If, when the eye has been for some time in a state of repose, either by shutting it or remaining a short time in the dark, we direct it to a feebly-illuminated surface, we shall see, upon opening it, a dark brown or reddish circular spot which quickly disappears, and which may be renewed by again closing and opening the eye. If, in place of being rested, the sensibility of the eye had been reduced by exposure to much light, the circular spot would have been bright, and more luminous than the illuminated surface. As the choroid coat lies behind the retina, and gives the vision of objects, whose images fall upon the foramen of the retina, it follows from the first experiment that the retina is more quickly affected with light than the choroid coat, and from the second, that the choroid coat is more readily impressed with light. The diameter of the foramen is about the 35th of an inch, and the angle subtended by the dark circular spot is about $4\frac{1}{2}°$, which corresponds with the other measure.[2]

Explanation of Natural Phenomena

In a very remarkable case, where the retina had been permanently rendered insensible by a blow on the head, Sir David Brewster found that vision was perfect over the space occupied by the *foramen centrale;* that is, when the image was received on the exposed part of the choroid. When a person was near the patient, he could only see his nose, or eye, or mouth, or a small portion of his face or figure; but he could recognise a friend at a distance when the whole of his face was included within a cone which bore to the foramen an angle of $4\frac{1}{2}°$.[3] The very same result was obtained in another case where the retina was only temporarily insensible.

Insensibility of the eye to direct impressions of faint light.

The insensibility of the retina to direct impressions of faint light was discovered by Sir David Brewster,[4] who found that when the eye directed its axis to objects faintly illuminated, it could not keep up a sustained vision of them. They disappeared and reappeared, and the eye was thrown into a state of painful agitation.

Duration of impressions on the retina.

When we shut the eye quickly after looking at an object, we see it for an instant (about the seventh part of a second) in its own colours; but this impression is instantly followed by an image of the object in its complementary colours. If we look at a window at the end of a long passage, we first see, after shutting our eyes, a picture of the window, with black bars and white panes; but after the seventh of a second the picture is one with white bars and black panes. When we whirl a burning stick, we see a complete circle of red light, although the burning end of the stick can only be in one part of the circle at the same instant.

Accommodation of the eye to different distances.

When objects are placed at different distances, the focus or point of distinct vision in the eye must vary. We feel that the eye has the power of adapting itself to these different distances so as to make the picture on the retina always distinct. How this is done has been long a matter in dispute. There can be no doubt, however, that the first step in the process is the variation of the pupil, which seems by a mechanism at the base of the iris to increase the distance of the lens from the retina.

Longsightedness.

At the age of about forty the eye loses this power of adaptation in consequence of the flattening of the crystalline lens, which renders it necessary to use a convex glass, which just compensates the flatness of the lens, and permits the eye to adjust itself as formerly.

Shortsightedness.

The opposite state of the eye, not produced by age, but rather diminished by it, is common even in young persons, arising either from a too great convexity or refractive power in the lens, or too great convexity in the cornea. In this state of the eye, the image is formed in front of the retina and a concave lens is necessary to correct it. This is called short-sightedness, which almost always decreases by age, in consequence of the crystalline lens becoming flatter.

Ocular spectra, or accidental colours.

When the eye looks steadily at a bright-coloured red wafer, and then looks at the white paper on which the wafer lies, it will see for a while a green one, the green being the

[1] See *Lond. and Edin. Phil Mag.*, Sept. 1832, p. 169.
[2] *Report of Brit. Assoc.* 1848, pp. 48, 49.
[3] *Report of Brit. Assoc.* 1852.
[4] *Edin. Jour. of Science*, No. vi., p. 288.

Optical Instruments.

accidental colour, or the *complementary* one to the red. The *green* image is called an *ocular spectrum*, as it has no real existence. The *accidental colours* and the original colours are the same as those given in Newton's Table, p. 604, where the *reflected* tints correspond with the original or *red* colour of the wafer, and the transmitted ones to the accidental colour, or *vice versa*; so that we can determine from that table the accidental colours of any coloured object upon which the eye may look steadily.

When the eye looks at the sun, or a bright image of it, the ocular spectrum is not *black*, but of various colours in succession, each colour being surrounded with a rim of its accidental colour.

Colours produced by the unequal action of light on the eyes.

The following beautiful experiment, showing the effect of light in diminishing the sensibility of the retina to particular colours, we owe to Mr Smith, surgeon at Fochabers. Hold a slip of white paper vertically about a foot from the eye, and direct both eyes to an object beyond it, the slip will appear double, and the two images equally white. Let a candle be brought near the right eye, so as to act strongly upon it without affecting the left, then the *left* image of the paper, or that seen by the right eye, will grow *green*, and the *right* hand image, or that seen by the left eye, will grow *red*, forming a beautiful contrast of colours. If the candle is brought round to the left eye, the images will first become of the same whitish colour, and then the *right* hand one will become *green*, and the left hand one *red*.[1]

Insensibility of the eye to particular colours.

The insensibility of the eye to particular colours is far from being uncommon. Professor Dugald Stewart, Dr Dalton, and Mr Troughton were unable to distinguish the colours at the red end of the spectrum. All red objects appeared green, owing to the insensibility of their retinas to red colours. This subject has already been treated of in our article on COLOURS, vol. vii., p. 153. (See Dr George Wilson's interesting volume *On Colour Blindness.*)

PART IX.—DESCRIPTION OF OPTICAL INSTRUMENTS.

Optical instruments.

The great number of optical instruments which have been described in different parts of this work renders it scarcely necessary to treat this subject in the general article. Under the articles BURNING GLASSES, CAMERA LUCIDA, KALEIDOSCOPE, MICROMETER, MICROSCOPE, PHOTOMETERS, and TELESCOPE, the reader will find some of the information which he might have expected here. There are instruments, however, so intimately connected with optics, and not previously described, which we must shortly notice, namely, the *Cylindrical Mirror*, the *Camera Obscura*, the *Magic Lantern*, and the *Phantasmagoric Machine*.

1. *Cylindrical Mirror.*

Cylindrical mirrors.

We have already (see p. 556) described the principle of cylindrical mirrors. If we suppose one of these mirrors, AB, fig. 276, to be placed on a table with the portrait of any person laid before it on the table, the reflected picture of the portrait in the cylindrical mirror will be distorted. If we take an accurate drawing of this distorted picture, and lay it before a cylindrical mirror, as shown at MN, where the human form can scarcely be recognised, we shall see in the cylindrical mirror its image reduced to symmetry.

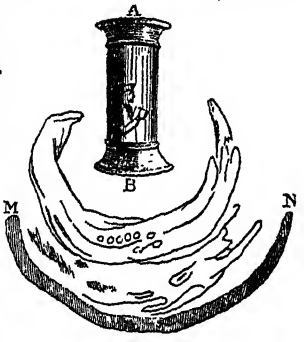

Fig. 276.

2. *On the Camera Obscura.*

Optical Instruments. Camera obscura.

We have already explained the principle of the camera obscura in treating of the images formed by convex lenses. The instrument is indeed nothing more than a convex lens placed in a suitable box, on the side or bottom of which an image of external objects is formed by the lens.

A convenient portable camera obscura for drawing objects is shown in fig. 277. The external object or landscape is reflected down into the lens AB by an inclined mirror CD. The rays thus falling vertically upon the lens are refracted to their foci, and form a distinct image of the landscape on the paper placed at EF. On one side of the box there is an opening through which the observer introduces his head and hand, care being taken, by a curtain of black cloth behind him, to exclude all extraneous light. M. Cauchoix of Paris has found that the best form of the lens for a camera is a meniscus having its convex surface towards the image, and its concave surface towards the object, and their radii of curvature as 5 to 8.

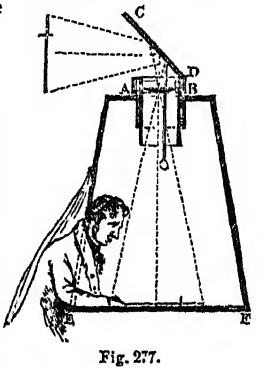

Fig. 277.

As an instrument essential in photography, the camera obscura has become one of the most important of our optical instruments, both in a scientific and commercial point of view. The most distinguished professional opticians have vied with each other in bringing it to perfection; and from the condition of a toy, it ranks in importance with the microscope and the telescope. In the article PHOTOGRAPHY will be found drawings and descriptions of the most approved cameras.

3. *On the Magic Lantern.*

Magic lantern.

The magic lantern, an invention of the celebrated Athanasius Kircher, is shown in fig. 278. It consists merely

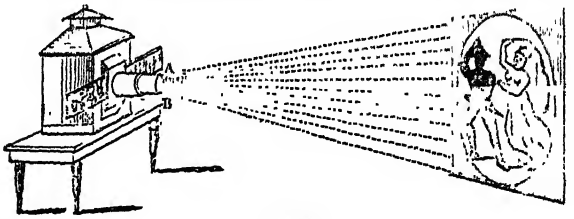

Fig. 278.

of a lens AB, which forms on the wall of a dark room a picture of any object placed before it, and at a greater distance than its anterior principal focus. The light of an Argand lamp is thrown in a condensed state by the illuminating lens D (figs. 279, 280), upon transparent varnished pictures painted on long sliders (fig. 281). The lens AB forms a large circle of light upon the wall, which, if it is not smooth

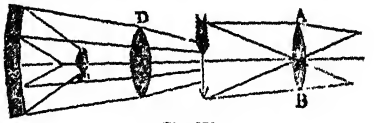

Fig. 279.

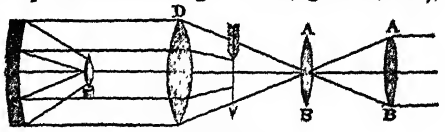

Fig. 280.

Fig. 281.

[1] An analysis of this and similar experiments will be found in the *Lond. and Edin. Phil. Mag.* 1832, p. 249

Optical Instruments.

and white, should be covered with a white, smooth cloth, and the images of the coloured figure appear within this circle.

A magic lantern is the same as a solar microscope, the sun being used for the source of light in the latter case, and natural objects in place of pictures. The *solar camera microscope*, invented by Dr Goring, and fully described in our article MICROSCOPE, vol. xiv., p. 791, and the oxyhydrogen microscope, described in the same article, may be considered as the most perfect magic lanterns that have been constructed, there being no difficulty in adapting them to give magnified representations of minute transparent paintings.

4. *On the Phantasmagoric Apparatus.*

Optical Instruments.

Phantasmagoric apparatus.

The apparatus for the phantasmagoria, or the raising of spectres, is nothing more than a magic lantern mounted upon wheels, which, in place of throwing its pictures upon an opaque white ground, upon which the spectator looks, throws them upon one side of an imperfectly transparent screen, the spectator viewing them on the other side of the screen. The direct light of a lamp A, (fig. 282), and the light reflected from the concave mirror B, is thrown upon the two illuminating lenses C, D, which

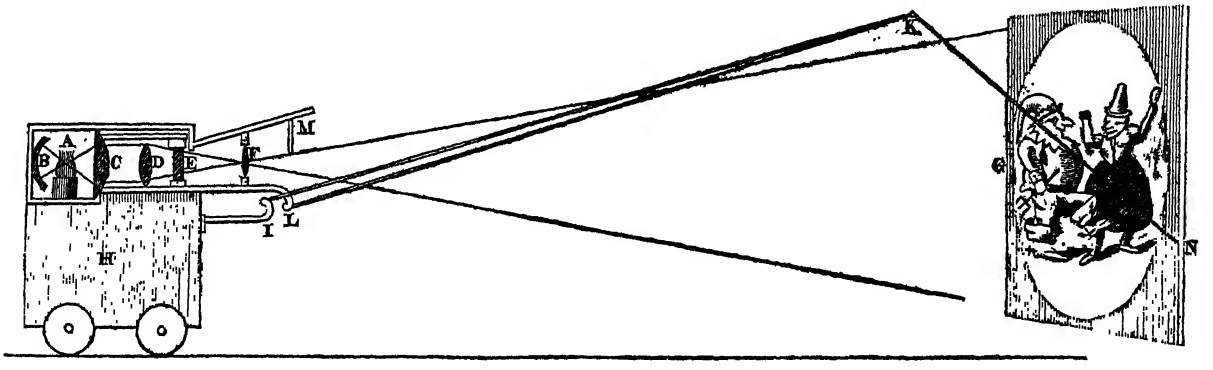

Fig. 282.

condense it, and thus strongly illuminate the spectres and figures painted upon sliders at E. These sliders are placed a little before the anterior focus of the magnifying lens F, which forms a highly-magnified picture of the figures on the transparent screen at G. When this apparatus is mounted upon a carriage with wheels, as at H, it may be made to approach to, or recede from, the screen G, in consequence of which the figures may be made to contract into dwarfs, disappearing in a point of light, or swell out into giants of enormous magnitude. In order, however, to have the pictures distinct at different distances of the apparatus from the screen, an adjustment is necessary, to make the distance EF increase as the apparatus approaches to G, and diminish as it recedes from it. With this view, the lens F is fixed to a slider, which may be drawn out by the general frame H. When this frame H is drawn away from the screen, the point K is brought lower by means of the rod IK, connected with another rod KN fixed to the frame of the screen at N, where there is a joint or centre of motion. The descent of the point K causes another lever KL to move the horizontal slider (which carries the lens F) in such a manner as to keep the screen always in the focus of F, and consequently the picture upon it always distinct. When the frame H, on the other hand, advances to the screen, the point K rises, and the lens F is again adjusted by the motion of the slider. When the images diminish and appear to vanish, the support of the lens F permits the screen M to fall and intercept part of the light. The screen M may have a triangular opening, so as to uncover the middle only of the lens F. In this adjusting apparatus the rods KN and KL must be equal, and the point I must be twice the focal length of the lens F before the object, L being immediately under the focus of the lens. The object of the screen M is to diminish the illumination of the objects as they get smaller and appear to retire from the spectator, because in the instrument they actually become brighter.

When M. Robertson exhibited this remarkable instrument, living persons were often strongly illuminated and introduced into the picture. The effect of life, however, was better given when the shadows of living objects only were introduced.

5. *On the Thaumatrope or Wonder-Turner.*

Thaumatrope or wonder-turner.

The *Thaumatrope* or *wonder-turner*, invented by Dr Paris, is a circular card with two strings made to whirl it rapidly round one of its diameters. If we draw a cage on one side of the card, and a bird on the other, and whirl the card round, we shall see the bird within the cage, the retina retaining the impression of both pictures, even when none of them are seen, which is the case when the edge of the card is directed to the eye.

6. *On the Phenakistoscope or Magic Disc.*

Phenakistoscope or magic disc.

This instrument was, we believe, originally invented by Dr Roget, and improved by M. Plateau, at Brussels, and Dr Faraday. It consists of a circular disc from six to twelve inches in diameter, with rectilineal apertures on its margin in the direction of its radii. A series of figures—of a rider, for example, leaping a fence—is drawn on the circumference of a circle parallel to the rim of the disc. The *first* figure represents the rider and horse standing *before* the fence, and the *last* figure represents them standing *over* the fence when the leap is completed. Between these two figures there are several others, representing the rider and the horse in different parts of the leap. The observer then stands in front of a looking-glass, with the disc in his left hand, attached to a handle, and by a piece of simple mechanism he whirls it rapidly round, looking at its image in the glass through the notches in its margin. He is then surprised to see the horse and his rider actually leaping the fence, as if they were alive, and returning and leaping again as the disc revolves. If we look over the margin of the disc, at the reflected picture on the face of the disc, all the figures are effaced, and entirely invisible; but when we look through the notches, we only see the figure of the horse and the rider at the instant the notch or aperture passes the eye, so that the picture instantaneously formed on the retina is not obliterated by preceding or subsequent impressions. Hence the eye receives in succession the pictures of the horse and rider in all the attitudes of the leap, which are blended, as it were, into one action. The apparent velocity with which the horse and

Optimism / Oracle.

rider advances (supposing the disc always to have the same velocity) depends on the proportion between the number of apertures in the margin of the disc and the number of figures of the horse and rider.

If we use a disc with three concentric circles of apertures, each containing different numbers—8, 10, and 12, for example; then, considering that these apertures revolve in the opposite direction in the reflected image, it is obvious that when we look through the circle of 10, which moves from left to right at the image of 10, revolving in the mirror from right to left, these opposite motions will destroy each other, and the circle of 10 apertures will appear to stand still in the picture. On the other hand, the circle of 12 apertures will always gain upon the one of 10, from which we look, and will appear to move from left to right with the difference of the velocities of the two, while the one of 8 will move backwards with the same difference. Oracle.

If we whirl a disc containing any word or figure upon it, without using a reflector, all is confused, and we cannot read the word or see the figure. Let it be whirled, however, in the dark, and let a spark of electricity, or the light of a little inflamed gunpowder, or of a percussion-cap, illuminate the disc, which it does only for an instant, and during that short instant the word or figure will be seen to stop, and we shall read the one and see the other with great distinctness.

(For further information on the subject of this article, see ASTRONOMY, vol. iv., p. 51, chap. iv.; ACHROMATIC TELESCOPES, BURNING GLASSES, CAMERA LUCIDA, CHROMATICS, COLOURS, KALEIDOSCOPE, METEOROLOGY, MICROMETER, MICROSCOPE, PHOTOGRAPHY, PHOTOMETER, STEREOSCOPE, and TELESCOPE.) (D. B.)

OPTIMISM is that philosophical doctrine which, starting from the absolute perfection of Deity, attributes to the universe, his work, the greatest possible perfection. This theory is to be found in some form or other in almost all the great speculative schools of antiquity, and especially among the philosophers of the Academy, of the Porch, and of Alexandria. Anselm and Aquinas were its chief advocates in the middle ages; its grandest developments, however, belong to modern times, and, in particular, to the schools of Descartes and Leibnitz. The splendid scheme of optimism advocated by the latter in his *Essais de Théodicée* is well known. (See DISSERTATION FIRST, part ii.)

OR (Fr. *gold*), one of the metals used in blazonry. (See HERALDRY.)

ORA, an old Saxon coin. (See COINAGE.)

ORACLE (Latin, *oraculum*, from *oris*, of the mouth) is a term applied in antient divination to the response of a deity, to the deity responding, or to the place where the response is delivered. The μαντεῖον and χρηστήριον of the Greeks were employed with nearly the same latitude of meaning; for they were used both for oracular responses and for the seat of the oracle. The origin of the belief in oracles may no doubt be traced to that desire to penetrate the mysteries of the future so characteristic of man in all stages of his development. And not only were oracular responses sought after as a means of gratifying this universal curiosity; they were also prized for the divine sanction which they lent to the undertakings of men. Jove, as the father and ruler both of gods and men, was, to the mind of a Greek or a Roman, the ultimate source of all divine revelations. But so far was he removed above the little affairs of men, that other lesser deities, and even heroes, had to be employed to transmit his will to earth. The oracles of Zeus were accordingly few, while those of other gods were very numerous.

The most elaborate oracular system of ancient times was to be found among the Greeks. What with Sibylline books, auguries, haruspices, and the like, the Roman did not find it necessary to call in the aid of oracular responses to disclose to him the future. The most celebrated oracles of the former people were those of Apollo. There are on record no fewer than twenty-two oracles at which this deity was consulted. These were Delphi, Abæ in Phocis, Ptoon in Thebes, Ismenion in Bœotia, Hysiæ in Attica, Tegyra in Bœotia, Eutresis near Leuctra, Orbiæ in Eubœa, the Lyceum at Argos, the Acropolis of Argos, Didyma in Miletus, Claros in Colophon, Grynea among the Myrinæans, Lesbos, Abdera, Delos, Patara in Lycia, Telmessus, Cilicia (two), Hybla in Caria, and Hiera Kome on the River Mæander. Of these oracles to Apollo, by far the most famous was that of Delphi. (For a full account of this celebrated oracle, see the article DELPHI.)

The revelations of Apollo were for the most part given by inspiration, while those of Jupiter were merely signs, which mortals had to interpret as best they could. (For the oracles of Zeus, see DODONA and OLYMPIA.) There was also an oracle to Jupiter Ammon in Libya, which had a considerable reputation (Herod. ii. 29, &c.; also iv. 181).

At Patræ in Achaia oracles were given by Demeter or Ceres concerning the recovery or death of the sick. In the centre of the market-place at Pharæ, in the same district, stood an altar to Hermes or Mercury, at which that deity was supposed to give responses to questions whispered in his ear. At Charax in Caria, was an oracle of Pluto and Cora, with a cave adjoining, in which sick persons slept and had cures revealed to them in their dreams.

In addition to those oracles of the lesser deities, the Greeks also consulted the oracles of certain heroes of distinction. Such were the oracles of Amphiaraus, near Thebes, and at Oropus (Herod. viii. 134); of Amphilochus at Mallos in Cilicia; of Trophimus at Lebadeia in Bœotia (Pausanias ix. 37, &c.); of Chalcas in Daunia; of Æsculapius at Epidaurus, and elsewhere; of Hercules at Bura in Achaia; of Pasiphaë at Thalamiæ; and of Phrixus in Iberia.

While the Greeks, as a rule, had recourse to oracles to discover the will of the gods, the Romans, on the other hand, trusted more to augury and the Sibylline books, for their knowledge of the future. The only Roman oracles with which we are acquainted were those of Faunus, near the Tibur, and on the Aventine; of Fortuna at Antium, Prænestе, and elsewhere; and of Mars at Tiora Matiena.

Oracular responses were given for the most part in Ionic hexameters, partly because the answers of the deity were thus rendered more venerable, and partly because verse had the advantage of being easily remembered. These oracular verses, however, exhibited occasional metrical defects,—and this even at the oracle of Apollo—which provoked the satirical remark, that the god of verse was sadly deficient in poetical accomplishment himself. To prevent this scandal, it is said that the responses were subsequently given in prose, and in the Doric dialect. These responses, as might naturally be expected, were notorious for their want of meaning, obscurity, or equivocation. Ample latitude was generally given for personal preference in interpreting them, and when they were at all intelligible, they generally displayed such an exquisite ambiguity that it was impossible for mortals to tell what they meant, or for the event to turn out different from some of their possible interpretations. The modes in which these deliverances were given were very various. At Delphi, they were uttered by the Pythia; at Dodona, they issued from a hollow rock; at the oracle of Jupiter Ammon, they were pronounced by the priests, who were very numerous. Painted dice were sometimes employed, as at Bura; and lots, sometimes consisting of lettered sticks of oak, were made use of, as in the case of the Italian oracle of Prænestе. A very

Oran.

frequent mode of oracular communication was through dreams, visions, and preternatural voices.

The Urim and Thummim, and the Bath Kōl of the Jews, are supposed by many to have borne a peculiar resemblance to the heathen oracle. (See Kitto's *Cyclopædia of Biblical Literature.*)

It was during the most flourishing period of Grecian history that oracles were held in greatest reverence and esteem. Every enterprise, no matter how private or trifling, had to receive the divine oracular sanction before it could be engaged in. Gradually, however, these mysterious deliverances lost their hold upon the public faith. The sceptical few always secretly ridiculed them as the offspring of subtle, unscrupulous priests. The philosopher smiled at them as a fresh illustration of human folly; and the politician, who held them in secret contempt, yet regarded them with public favour as a means of advancing his own designs. (See Cicero, *De Divinatione.*) "On what account, Labienus," says Cato, in that celebrated passage of Lucan's *Pharsalia*, lib. ix., "would you have me consult Jove? . . . . Let us not ask him to repeat to us what he has sufficiently written on our hearts. Truth hath not retired into these deserts: it is not recorded on the sands of Libya. Let the irresolute and unstable have recourse to oracles; for my part, I can extract the most steadfast resolution from everything in nature. Death comes to the coward as well as the brave. Jupiter can tell us no more."

While some have believed in the genuine divinity of oracular responses, and others have scouted them as the inventions of designing men, a third party have attributed them to the influence of the devil. The latter view was entertained by the Christian fathers; the second is maintained by Hüllmann (*Würdigung des Delphischen Orakels*, Bonn, 1837), at the present day; while the first finds a partial advocate in Klausen. (See art. "Orakel" in Ersch and Gruber's *Encyclopädie*). Much controversy has also been created respecting the period at which oracles ceased altogether to give forth their deliverances. Eusebius advanced the opinion, and the majority of Christian writers have followed him, that all oracles became silent at the birth of Christ. Milton has adopted this view in his grand *Hymn of the Nativity.* But traces remain of their having been consulted as late as 358 A.D.; and edicts are known to have been issued against them by the emperors Theodosius, Gratian, and Valentinian. Oracles had long before lost their hold on the public, however, and what faint traces of the superstition still lurked in remote corners gradually disappeared before the superior light of Christianity.

(On the general subject of Greek and Roman oracles, see Wachsmuth, *Hellen. Alt.*, vol. ii.; Hartung, *Die Relig. der Römer;* Niebuhr's *History of Rome;* and the *Encyclopédie Moderne.* Also the works of Daniel Clusens (1673), Anton Van Dale (1683), E. Dickinson (1686), Fontenelle (1687), J. C. Bulenger (1699), and Clavier (1819). On the Delphic oracle, see the works of C. F. Wilster, Piotrowski, and W. Götte; also those of Hüllmann and Klausen, already referred to. On the oracle at Dodona, see the works of Cordes, Arneth, and Lassaulx.)

ORAN, a seaport-town of Algeria, capital of a military division and of a prefecture, stands at the head of a bay on the Mediterranean, 209 miles W.S.W. of Algiers; N. Lat. 35. 44., W. Long. 0. 41. It is built on the two slopes of a ravine, which is traversed by a stream, here crossed by two bridges. As it is for the most part of modern origin, the streets are regular, and lined with handsome buildings. The defences of the place consist of three forts, which command the roadstead of Oran, and the road to the neighbouring harbour of Mers-el-Kebir, one of the best on this coast. The parish church was originally a Mohammedan mosque; and another church, now connected with an hospital, was built by the Spaniards in the time of Charles V. There are also an arsenal, artillery and cavalry barracks, and some fine gardens. The roadstead at Oran is bad and unsheltered; but the harbour of Mers-el-Kebir is only 3 miles to the north of the town. By means of this port a considerable trade is carried on with Morocco and Spain. Oran was taken by the Spaniards in 1509, and occupied by them till 1708. They again obtained possession of the town in 1732; but in 1790 it was much injured by an earthquake, and more so by the Moors, who besieged the town, and compelled the Spaniards to surrender it. When the French, in 1830, established themselves here, it was in a very ruinous condition. It is now, however, the second Christian city in Algeria, with a population of 20,775, of whom 13,560 are Europeans.

Orange ‖ Orange River.

ORANGE, a town of France, capital of an arrondissement of the same name, in the department of Vaucluse, in the middle of a beautiful and fertile plain, about 3 miles from the left bank of the Rhone, and 13 north of Avignon. Many of the houses are handsome; but the streets are narrow, crooked, and not well kept. There are several elegant public fountains, well supplied with water. The most remarkable and splendid buildings are those which have remained from the time of the Romans, under whom Orange was known by the name of *Arausio.* About one-fourth of a mile from the town stands a triumphal arch in very good preservation, built of limestone of a deep yellow tint, in the Corinthian style of architecture. It has one central archway, with two smaller ones at the sides, and is profusely adorned with sculptures of naval trophies. No inscription can be traced on the arch, except the single word "Mario," which has led to the supposition that it was erected to commemorate the victory of Marius over the Teutones at Aix in 102 B.C.; but it is with probability believed that the arch is of much later date. The Roman theatre stands on the slope, and at the foot of a hill at the other end of the town, and is of semicircular form. The chord of the semicircle is formed by a colossal wall 121 feet high, 334 long, and 13 thick. The exterior of this wall forms a magnificent front of five stories, with a large central archway supported by Corinthian pillars. In the interior are to be seen all the parts of an ancient theatre, though entirely stripped of its ornaments. Near the theatre are the remains of an ancient circus; and many sculptures, pillars, and slabs of marble have been found in the town. There are still some traces of the walls that surrounded the ancient Arausio, which, from the extent of these defences, may have contained a population of 40,000. The modern town contains a court of the first instance, a council of *prud'hommes*, a public library, college, &c. In the middle ages, Orange was the capital of a small independent principality, which belonged to several families, and finally to that of Nassau. The territory was ceded to France by Frederick William of Prussia at the treaty of Utrecht; but the title has still continued in the family of Nassau, and is now borne by the heir to the throne of Holland. Orange has manufactures of silks, cottons, handkerchiefs, serge, &c.; and there is some trade in corn, wine, brandy, oil, honey, and wool. Pop. (1856) of the town, 9685; of the arrondissement, 75,260.

ORANGE RIVER, or *Gariep*, a river of South Africa, bounding Cape Colony on the north, rises about 10,000 feet above the level of the sea, in S. Lat. 28. 40., E. Long. 28. 30., and flows first S.W., then N.W., and finally westward, in an irregular course, till it falls into the Atlantic, S. Lat. 28. 30., E. Long. 16. 30. Gold and copper ore have been found near its banks. The Orange River receives several tributaries, both from the north and from the south. The largest of these is the Ky-Gariep, Vaal, or Yellow River, from the north, which has a longer course than the Orange River itself. The Kuruman, and the Borradaile or Fish River, also join it from the north; and the

Hartebeest or Visch River from the south. The length of the river, from the source of the Vaal to the sea, is 1000 miles.

ORANGE RIVER SOVEREIGNTY, a tract of country lying between the rivers Orange and Vaal, to the N.E. of Cape Colony, having an extent of 60,000 square miles. It was made a British territory in 1848, but was abandoned in 1854.

ORANGE, the fruit of the sweet-orange tree (*Citrus aurantium*, Risso, Nat. Ord. *Aurantiaceæ*). This now well-known fruit is by no means an old inhabitant of Europe. Its native country is India, and perhaps China, but its introduction into Europe is possibly due to the Moors, who certainly introduced and planted extensive groves of the bitter orange at Seville and other places in Spain. The sweet orange bears the climate of the south of Europe exceedingly well, and in consequence has been most assiduously cultivated in Spain, Portugal, Italy, and Sicily. The result has been the production of a great number of varieties, no less than nineteen of which have been described by Risso, the historian of the cultivated orange. The foliage of the orange is very beautiful, and forms a large round head to a short but well-formed stem, which is for 5 or 6 feet free from branches. The flowers are white and unattractive, but have a most delicious fragrance; so also has the fruit, both in its green and ripe state. The odour of the fruit resides in the outer coating of the rind, which when ripe is of a golden-yellow colour; this is technically called the *flavedo*. It is usual for the orange tree to have almost constantly flowers, with green and ripe fruit at the same time. For the oils obtained from the orange, see OILS. The cultivation of the orange constitutes a most important branch of industry in Italy, Spain, Portugal, and the Azores, which countries supply the greater portion of this fruit consumed in Europe. Many of the plantations in Spain are of considerable age; but the oldest are those formed by the Moors in the neighbourhood of Seville of the bitter orange (*Citrus Bigaradia*, Rissso), the fruit of which is sold under the name of "Seville oranges" for the manufacture of marmalade and other confections. The rind is also used in medicine as an agreeable tonic. When intended for export to other countries, the fruit is gathered a little before it is ripe, and each orange is wrapped either in thin paper or the spathes of Indian corn, and afterwards packed in chests or boxes,—the former containing about 800, and the latter 300. The chief places of import in this country are London, Liverpool, and Hull; and the quantity imported is immense. In 1857 we received from Portugal 229,116 bushels; the Azores, 274,200 bushels; Malta, 2430 bushels; Spain, 68,436 bushels; Two Sicilies, 112,510 bushels; Gibraltar, 3550 bushels; and from other countries 2600 bushels;—in all, 692,842 bushels, as nearly as can be ascertained; but there is some uncertainty as to the exact quantity, owing to oranges and lemons being given together in the government returns. The duty on oranges is at present (1858) 8d. per bushel. A curious and delicious variety of the orange is grown in Brazil, and occasionally sent in small quantities to this country; its rind does not perfectly inclose the pulp, as in the common orange, but breaks up into several portions at the top of the fruit, which is lemon-shaped, and very large. It is the *Larangeira embeguda*, or "navel-orange" of orange cultivators. (T.C.A.)

ORATORIO, in music, a kind of sacred drama, in which the poetry is derived from some Scriptural subject, and is set to music in recitatives, airs, duetts, trios, quartetts, &c., and choruses, accompanied by an orchestra, sometimes an organ, and introduced by an instrumental overture. The origin of the oratorio is not clearly established. Amongst the most remarkable oratorios of modern times is Haydn's "Creation." (G. F. G.)

ORATORY. See RHETORIC.

ORAVICZA, a town of Hungary, in the Banat, circle of Lugos, 53 miles S.S.E. of Temesvar. In the vicinity are mines of gold, silver, copper, iron, and coal. The town is the seat of a board of mining for the Banat, and of some weaving establishments. Pop. 4840.

ORB, a town of Bavaria, circle of Lower Franconia, 41 miles N.N.W. of Wurtzburg. It has rich salt mines, producing annually upwards of 1800 tons of salt; numerous mills, mineral springs, and an active transit trade. Pop. 4500.

ORCAGNA, or ORGAGNA, ANDREA, a celebrated Italian artist, was the son of Cione, a well-known goldsmith, and was born at Florence in the former half of the fourteenth century. His artistic talents were displayed at once in painting, sculpture, architecture, and poetry. He was first engaged, along with his brother Bernardo, in decorating churches. His chief pictures were "The Triumph of Death," and "The Last Judgment," both of which exist at the present time in the Campo Santo at Pisa, and bear testimony to the spirited and fertile invention of the artist. Then turning his attention to sculpture and architecture, he erected and ornamented the finely-proportioned Loggia di Lanzi and the church of Or San Michele, two edifices which are still seen in his native city. Meanwhile his leisure hours had been occupied in making verses; and he now continued to dabble in poetry till his death, at the age of sixty. (Vasari's *Painters, Sculptors*, &c.; and Lanzi's *History of Painting*.)

ORCHARD. See HORTICULTURE.

ORCHESTRA (Gr. ὀρχήστρα) was the place allotted to the chorus in the Greek theatres; but it signifies in modern times that place occupied by the instrumental band in a theatre, or by the instrumental and vocal performers in a concert-room. The word *orchestra* is also used as synonymous with *band*. In the Leipsic *Musical Gazette, passim*, there are plans and descriptions of some of the most celebrated orchestras—that of the Grand Opera at Paris, of a grand amateur concert at Vienna, of the San Carlo Theatre at Naples, of the Scala Theatre at Milan. (See also Burney's account of the great Handel commemoration in Westminster Abbey in May 1784; and the published accounts of the Handel commemoration in the Crystal Palace in 1857. For remarks on orchestral instrumentation, see article MUSIC.) (G. F. G.)

ORCHESTRINO, a modern musical instrument, so called by its inventor Poulleau. It was shaped like a pianoforte, had similar finger-keys, and its sounds were produced by the friction of a circular bow upon the strings. It imitated the tones of the violin, the viola, the violoncello, the the viol d'amour, the double-bass, &c. The construction of the bow (of hair, &c.) is said to have been very curious and ingenious. (G. F. G.)

ORCHESTRION, a musical instrument invented by the Abbé Vogler about 1789. It was a kind of portable organ, about 9 feet in height, breadth, and depth. Its power was that of an organ of 16-feet pipe, and it had a mechanism to swell or to diminish all the sounds within its compass. Another instrument of the same name, invented in 1796 by Kunz, a Bohemian, consisted of a pianoforte combined with some organ-stops. (G. F. G.)

ORCHILLA WEED, the commercial name applied to several species of *Rocella* (Nat. Ord. *Lichenes*). The most common is *R. tinctoria*, De Cand., which, although found growing on the rocks of European coasts even as far north as Britain, is chiefly collected on the tropical coasts of Lima and Angola. From the same localities, and also now in considerable quantities from India, *R. fuciformis* is also collected and exported. These are often mixed with other species, as *R. dichotoma*, *R. pygmæa*, *R. flaccida*, &c. These lichens are foliaceous, branched like a stag's horn, but generally flat. Their colour is a greenish-gray; and they have a peculiar and agreeable odour, resembling primroses, when in large quantities. When reduced to a pulp, and mixed with an ammoniacal liquor, they yield, after macera-

Orchomenus.

tion and fermentation, a beautiful purple colour, which is called *orchil* or *archil*. Beckmann (*History of Inventions*) narrates the accidental discovery of the colouring properties of this plant by a Florentine merchant, which serves to explain the fact that this rich dye was so long a secret, known only to the Florentines. It is more than probable, however, that the *Phycos thalassion* of Theophrastus and Dioscorides, used in their time for dyeing wool, and collected for that purpose in the Greek islands, was one of the species of Rocella. This dyeing material varies very much in price. It has been sold as high as L.1000 per ton; but it now ranges from L.30 to L.70. The quantity imported in 1857 was 998 tons, the greater part of which was from Portugal and Lima. (T. C. A.)

ORCHOMENUS, a city of Bœotia, and the capital of the powerful tribe the Minyæ, was situated near the western shore of the Copaic Lake, on a hill which overlooked the windings of the Cephissus. Its original inhabitants are said to have been Thessalian emigrants, and its ultimate name was derived from Orchomenus, one of the kings of the Minyans. The city seems to have been powerful and important from the very first. Its wealth was likened by Homer to that of the Egyptian Thebes; its contingent of ships to the Trojan war amounted to thirty; it seems at one time to have had jurisdiction over the towns of the neighbourhood; and even when, shortly after the destruction of Troy, it was forced into the Bœotian confederacy, it was second among the allies to Thebes alone. The decline of Orchomenus may be said to have commenced in 395 B.C., when, averse to the democratic government of the Thebans, it took the field with Sparta in support of oligarchy. It is true that its cause triumphed at the battle of Coronea in 394 B.C., and that its independence was secured by the peace of Antalcidas in 387 B.C. Yet Thebes had contracted a deadly enmity against its former tributary, and only waited for an opportunity to inflict revenge. In 371 B.C. the victory of Leuctra, which restored to the Thebans their supremacy over Bœotia, afforded this opportunity. Orchomenus was destroyed, and its inhabitants were sold for slaves. It rose again not long afterwards, only to be destroyed in 346 B.C., by its implacable foes; and although its walls were rebuilt once more by the command of Philip of Macedon, it had sunk into ruins in the time of Strabo. When visited by Pausanias, the remains of Orchomenus contained a temple of Bacchus; the tomb of Hesiod; the tomb of Minyas, an ancient king of the town, who gave his name to the Minyans; and a temple in which a famous festival in honour of the Graces had been wont to be held. The fortifications can still be traced near the village of Skripú. (Müller's *Orchomenos und die Minyer;* Leake's *Northern Greece;* and Mure's *Tour in Greece.*)

ORCHOMENUS, an ancient city of Arcadia, stood in a plain surrounded by hills which separated its territory from that of Mantinea on the S., and those of Pheneus and Stymphalus on the N. Its founder is said to have been Orchomenus, the son of Lycaon. Its situation, in the midst of a well-watered valley, and its acropolis, upon a high and impregnable hill, seem to have rendered it in early times a very important city. Homer calls it "rich in flocks;" and several of its kings are said to have spread their rule over all Arcadia. But during the Peloponnesian war, when its acropolis had probably fallen into ruins, and when its last king, Pisistratus, had been murdered by an oligarchical faction, Orchomenus began to decline. About 367 B.C. three of its tributary towns were depopulated to furnish inhabitants to the newly-founded city of Megalopolis; in 313 B.C. it was taken by the Macedonian general Cassander; and ever afterwards it continued to be bandied about between different belligerent powers. Yet, in the time of Pausanias, Orchomenus was still inhabited, and at the present day its ruins are seen near the village of Kalpáki.

Ordeal.

ORDEAL, a term applied to an ancient form of trial, derived from the Anglo-Saxon *ordael*, compounded, according to Spelman and Ducange, of *or*, great, and *dael*, judgment. Lye and Bosworth derive it from *or*, without, and *dael* difference; signifying thus a judgment without a difference or distinction of persons, or, in other words, an impartial judgment. It agrees with the German *urtheil.* (See Hickes, *Dissert. Epistol.*, p. 149.) It consisted in an appeal to the immediate interposition of Divine power, being particularly distinguished by the appellation of *judicium Dei;* and was sometimes called *purgatio vulgaris*, to distinguish it from canonical purgation, which was by oath.

That the purgation by ordeal, of some kind or other, is very ancient, admits not of a doubt; and that it was universal in the times of superstitious ignorance, seems to be equally certain. Perhaps the earliest trace of this practice is to be found in the book of Numbers, chap. v., where Hebrew women suspected of incontinency had to drink the "waters of jealousy" as a test of their innocence. The ordeal of the "red drink," employed by the inhabitants of the Gold Coast in Africa, resembles this Jewish custom not a little. (See Kitto's *Biblical Cyclopædia.*) It appears even to have been known also to the ancient Greeks; for in the *Antigone* of Sophocles a person suspected by Creon of a misdemeanour, declares himself ready "to handle hot iron and to walk over fire," in order to manifest his innocence, which, the scholiast tells us, was then a usual mode of purgation. And Grotius gives many instances of water-ordeal in Bithynia, Sardinia, and other places. It seems, however, to have been carried to a greater height amongst the Hindus than ever it had been in any nation or amongst any people, however rude or barbarous; for in a paper in the *Asiatic Researches* (vol. i., p. 389), communicated by Hastings, we find that the trial by ordeal amongst that people is conducted in nine different ways: by the balance; by fire; by water; by poison; by the *cosha*, or the water in which an idol has been washed; by rice; by boiling oil; by red-hot iron; and by images. Two kinds of this trial were more common than the rest, at least in Europe,—viz., fire-ordeal and water-ordeal. The former was confined to persons of high rank, the latter to the common people. Both these might be performed by deputy; but the principal was bound to answer for the success of the trial, the deputy only venturing some corporal pain, for hire, or perhaps for friendship; hence the origin of the expression "to go through fire and water" for one. "Fire-ordeal," says Blackstone (*Comm.*, vol. iv., c. 27), "was performed either by taking up in the hand, unhurt, a piece of red-hot iron, of one, two, or three pounds weight; or else by walking, barefoot and blindfold, over nine red-hot ploughshares, laid lengthwise at unequal distances; and if the party escaped unhurt, he was adjudged innocent, but if it happened otherwise, as without collusion it usually did, he was then condemned as guilty. However, by this latter method Queen Emma, the mother of Edward the Confessor, is mentioned to have cleared her character when suspected of familiarity with Alwyn, Bishop of Winchester." "The water-ordeal was performed either by plunging the bare arm up to the elbow in boiling water, and escaping unhurt thereby; or by casting the person suspected into a river or pond of cold water, and if he floated therein without any act of swimming, it was deemed an evidence of his guilt, but if he sunk he was acquitted."

The origin of this mode of trial may be traced to necessity as well as to superstition. At the time in which it originated in England, as well as in other countries of Europe, it was no easy matter for an innocent person, when accused of guilt, to get himself cleared by the then established mode of trial. It was therefore natural for superstition to fly to heaven for those testimonies of innocence which the ab-

Orders. surdity of human laws often prevented men from obtaining in the ordinary course of affairs. In this way, doubtless, did the trial by ordeal commence; and being thus begun by necessitous superstition, it was fostered by impious priestcraft and unjust power. (See JURY TRIAL.) Besides the particular methods of trial which we have already mentioned, there were some few more common in European countries; as the judicial combat, the ordeal of the cross, and the ordeal of the *corsned*.

The judicial combat was exceedingly common in Germany in very remote ages; but it is not mentioned in any of the Anglo-Saxon laws, and it does not appear to have been much used in England until after the Conquest. It was so much the custom in the middle ages of Christianity to respect the cross, even to superstition, that it would indeed have been wonderful if the same ignorant bigotry had not converted it into an ordeal; and accordingly we find it used for this purpose in so many different ways as almost to preclude description. The corsned, or the consecrated bread and cheese, was the ordeal to which the clergy commonly appealed when they were accused of any crimes. If the culprit swallowed the bread and cheese freely, he was declared innocent; but if it stuck in his throat, he was pronounced guilty. In the reign of Edward the Confessor, as historians assure us, Godwin, Earl of Kent, in abjuring the death of the king's brother, appealed to this ordeal, and was choked by the corsned. (Blackstone, vol. iv.)

Besides these, there were a variety of other ordeals practised in Christian countries, many of which retain the same names which were used amongst pagans, and differ only as to the mode in which they were performed. In all nations of Christians where these trials were used, we find the clergy engaged in them. Indeed, in England, as late as the time of King John, we find grants to the bishops and clergy to use the *judicium ferri, aquæ, et ignis;* and both in England and Sweden the clergy presided at this trial, and it was only performed in the churches, or in other consecrated ground. But we find the canon law, at a very early period, declaring against trial by ordeal, or *vulgaris purgatio*, as being the work of the devil. A decree to this effect was issued in the eighteenth canon of the fourth Lateran Council, November 1215. "Upon this authority, though the canons themselves were of no validity in England, it was thought proper," says Blackstone (as had been done in Denmark above a century before), to disuse and abolish this trial entirely in our courts of justice by an act of Parliament 3 Henry III., according to Sir Edward Coke, or rather by an order of the king in council. Spelman thinks, however (*Glossary* under *Judicium Dei*), that this law was merely temporary. It is clear that it must have fallen into disuse in England about the middle of the thirteenth century, as it had in most European nations long before. (Seldon's *Notes* to Eadmer; see also Palgrave's *Rise and Progress of the English Commonwealth*, vol. i., p. 256.)

That much priestly jugglery was practised in connection with ordeals there can be no manner of doubt. Artificial preparations were known and used which enabled the suspected to undergo the most unheard-of trials without injury. With the scientific knowledge of the present day this seems in no way so miraculous as it must have done to the ignorant of those early times. When the ordeal was abolished, and this art rendered useless, the clergy no longer kept it a secret.

ORDERS. In no Reformed church are there more than three orders, namely, bishops, priests, and deacons. In the Roman Catholic church there are seven, exclusive of the episcopate, all of which the Council of Trent enjoins to be received and believed, on pain of anathema. They are distinguished into petty or secular orders, and major or sacred orders.

The petty or minor orders are four; those of doorkeeper, exorcist, reader, and acolyte. Persons in petty orders may marry without any dispensation. In effect, the petty orders are looked on as little other than formalities, and as degrees necessary to arrive at the higher orders. The Greeks disavow these petty orders, and pass immediately to the subdiaconate; and the Reformed churches to the diaconate. Their rise Fleury dates in the time of the Emperor Justinian. There is no call nor benefice required for the four petty orders; and even a bastard may enjoy them without any dispensation, nor does a second marriage disqualify. Orders ‖ Ordination.

ORDERS, *Religious*, in the Romish Church, are generally reckoned three,—viz., the *monastic*, the *military*, and the *mendicant*. (Respecting these, see MONACHISM, KNIGHTS AND KNIGHTHOOD, MENDICANTS, and JESUITISM.)

ORDERS, *Holy*. See ORDINATION.

ORDERICUS, VITALIS, author of a very valuable history of England and Normandy during the eleventh and twelfth centuries, was born at Attingesham (*Atcham*), a village on the Severn, near Shrewsbury, on the 17th of February 1075. Our information respecting his life is confined entirely to his own writings. His father, Odelerius, quitted his native city of Orleans to accompany Roger de Montgomery into England, and received from that lord a grant of lands near Shrewsbury, where he built a monastery, to which he retired in 1110. The child received the name of *Ordericus* after the priest who baptized him. At the age of five years he was sent to school at Shrewsbury, where he remained under the care of Siward, a priest, till his tenth year. His father then gave him in charge to Raynold, a monk, who conveyed him to the abbey of St Evroult, in the diocese of Lisieux in Normandy, and dedicated the boy to a monastic life. Ordericus received the tonsure in 1085, and assumed the name of *Vitalis* in honour of the saint whose memory was solemnized on the day of his admission to the monastic order. He attained afterwards to the rank of priest. The remainder of his days were devoted to the peaceful performance of the duties of his order, and to the composition of his *Ecclesiastical History of England and Normandy*. The rules of the cloister were not compatible with the gratification of his strong inclination for travel; yet he was permitted occasional absence for the purpose of collecting materials for his History. With this intention, he visited Croyland Abbey and Worcester on two separate occasions, besides making various journeys to different parts of Normandy. In 1141 he draws his History to a close, "worn out by age and infirmities." He was then in his sixty-seventh year, and must have died soon after. Although removed from his native country while yet a mere child, he never ceased to glory in the name of *Englishman*, and describes himself in the title of his great work as *Vitalis Angligena*.

His History, which consists of thirteen books, seems to have been written in a very irregular manner. What stand now as books first, second, and seventh, were composed after the rest of the work had been completed. M. Guizot says of it in his Introduction to the French edition, "On more than one occasion his materials seem thrown together pell-mell, as chance or opportunity brought them into the author's power. But this irregular surface covers a mine of real wealth. No book contains so much and such valuable information on the history of the eleventh and twelfth centuries—on the political state, both civil and religious, of society in the west of Europe—and on the manners of the times, whether feudal, monastic or popular." The entire work of Vitalis was first printed in the collection of Duchesne in 1619; a French version of it by Dubois appeared in 1826; another, by Le Provost and Delisle, 1838–54; and an excellent English version, by T. Forester, was published in 4 vols. by Bohn, London, 1853–56.

ORDINATION is the solemn setting apart to the work

Ordination. of the Christian ministry in a congregation, or the act of investing with the sacred office in the Christian church.

The *form* in which this rite is administered is substantially the same in all sections of the church; but the rite has a very different *signification*, and is viewed with very different feelings, in different communions. These differences are determined chiefly by the views entertained of the nature of the sacred office itself, and of the relation of those invested with it to each other. Where a gradation of rank and authority obtains within the clerical body, and where the Christian ministry is regarded as a priesthood, it is obvious that ordination must have a very different meaning from what is attached to it by those who hold the parity of the clergy, and regard their functions as purely ministerial, and in no respect sacerdotal. In the former case ordination will mean to confer orders (*conferre ordines*); in the latter it cannot mean more than to receive into the body (*cooptare in ordinem*).

We shall best consult, we believe, the wishes of our readers if, without entering polemically into this thorny question, we place before them, from authentic sources, a statement of the opinions entertained by the leading sections of the church regarding ordination.

By the *Roman Catholics* ordination is regarded as a sacrament, and in its highest degree it is the investing with the priestly office and the conferring of priestly powers. To this there are several preliminary steps, which ascend in the following order:—The ostiariate, the lectorate, the exorcistate, the acolythate, the subdiaconate, and the diaconate[1] (*Concil. Trident.* Sess. 22, c. 2. Comp. *Concil. Carthag.* iv. c. 3—c. 9, in Caranza, *Summa Conc.*, p. 167.) Through each of these steps the candidate ought regularly to pass; but in practice this rule is not always strictly followed, inasmuch as, when the service of the church requires, it is assumed that the proved fitness of a candidate for the higher stage renders it unnecessary that he should formally pass through the lower stages (Schnappinger, *Doctrina Dogmatum Eccl. Christ. Cathol.*, vol. ii., p. 194). Ordination can be administered only by a bishop, who is a successor of the Apostles, and in whom resides the faculty of communicating ecclesiastical authority and sacerdotal power. By imposition of hands upon the candidate, accompanied with the words, "Accipe potestatem offerendi sacrificium pro vivis et mortuis in nomine Patris, Filii, et Spiritus Sancti," the bishop performs the act of ordination; and the individual so ordained becomes thenceforward endowed with the Holy Spirit, and capable of offering the sacrifice of the altar, and of remitting or binding sins. The character thus impressed upon him is indelible; the priest can never again become a laic, even though he may cease to discharge the functions of his office. A recent expositor of Roman Catholic theology has thus stated the effect of ordination in relation to the three superior grades of the clergy:—"The working of ordination is the sacerdotal grace, the power of the Holy Ghost, and that in such a way as that the fulness of the priesthood shall belong to the episcopate, on which account bishops are the chief servants and organs of grace, and they who communicate the Holy Ghost in confirmation and ordination; a lesser portion falls to the priests, to whom is given the power of offering sacrifice and absolving; whilst on the deacons comes only a beginning and shadow of the priesthood, to whom are committed only the preaching, the preparation and distribution of the eucharistic offering, and the dispensing of baptism." (Klee, *Kath. Dogmatik*, iii. 338.)

In the *Greek Church*, ordination is regarded in much the same light as in the Romish church. "The priesthood," says the *Confessio Orthodoxa*, p. 173, "inasmuch as it is a sacrament (μυστήριον), was appointed to the Apostles by Christ; and ordination (χειροτονία) takes place by the imposition of their hands even unto our day, the bishops having succeeded them for the communication of the holy mysteries, and the ministry of the salvation of men." Ordination.

In the *Anglican Church*, there are some whose views of ordination very slightly differ from those avowed by the Romanists (see *Tracts for the Times*, No. 4, and No. 54, &c.) But the judgment of the church, as such, is more justly expressed in the following statement. Ordination is 'a privilege peculiar to the character of a bishop, who is a governor in the church of God; whereby he conveys authority to some to preach the gospel, and to administer the sacraments, who are called *presbyters*, and from whence is derived our word *priest*; and to others to be assistants to himself and the presbyters in their spiritual administrations, who are called *deacons*; which is performed by prayer and the imposition of hands—a solemn ceremony of blessing and devoting persons to the sacred function." (Nelson's *Companion for the Festivals and Fasts of the Church of England*, p. 526, 22d edit.) The Church of England formally repudiates the sacramental character of orders in her 25th article, but attaches importance to ordination, as needful for the maintenance of that "reverend estimation" in which the ministerial office ought to be held in the church. The right of ordaining is vested in the bishop, who is bound to satisfy himself that the candidate is "a man of virtuous conversation, and without crime," and that he is "learned in the Latin tongue, and sufficiently instructed in holy Scripture." No one can be ordained a deacon under twenty-three years of age, unless he have a Faculty; and every one who is to be admitted a priest must be full four-and-twenty years old. The canonical seasons for ordination are the Sundays immediately following the four ember days; that is, the second Sunday in Lent, the Sunday after Whitsunday, the Sunday after the 14th of September, and the Sunday after the 13th of December (*Can.* 31); but on urgent occasions, according to the discretion of the bishop, ordination may be administered on any other Sunday or holy day, provided it be done "in the face of the church." The parties to be ordained are presented to the bishop by the archdeacon or his deputy, who is bound to attest their meetness for the office to which they aspire. After administering to each the oath of allegiance, and exacting from them an avowal of their conviction that they are moved by the Holy Ghost to take on them the sacred office, a profession of their belief in the canonical Scriptures, and a promise to read them diligently to the people, as well as to live so as to be an example to the flock, the bishop ordains them by laying his hands severally on the head of each, and pronouncing over each the formula of authorization to discharge the functions of the office to which he is set apart. In the case of deacons, this authorization is limited to the reading of the gospel in the church, and the preaching of the same if licensed thereto by the bishop himself. In ordaining priests, the bishop says, "Receive the Holy Ghost for the office and work of a priest in the church of God now committed unto thee by the imposition of our hands. Whose sins thou dost forgive they are forgiven, and whose sins thou dost retain they are retained. And be thou a faithful dispenser of the Word of God and of his holy sacraments; in the name of the Father, and of the Son, and of the Holy Ghost. Amen." After this, the bishop delivers to every one of them, kneeling, the Bible into his hand, saying, "Take thou authority to preach the Word of God, and to minister the holy sacraments to the congregation where thou shalt be lawfully appointed thereunto."

[1] Whether all of these are to be counted sacramental is a point not fully settled in the Romish Church. Bellarmine refers to the different views, and concludes,—"Absolute tamen probabilior sententia est, quæ ordines omnes sacramenta esse docet quam ea quæ negat." (*Sacr. Ord.*, c. 5.)

Ordination.

The *Lutherans* repudiate alike the sacramental character of ordination and the priesthood of the clergy. Preserving as a sacred truth the idea of the universal priesthood of the people of God in a spiritual sense, they deny the existence of any *essential* distinction between the clergy and the laity, and regard the sacred office as simply a ministry, not in any particular congregation, but in the church at large—a ministry the special function of which is to preach the Word of God, to administer the sacraments, and to remit or retain sins (see *Apol. Confess. Aug.*, art. 7, art. 10, art. 14; *Conf. Aug.*, art. 5). Ordination is with them, consequently, simple consecration or designation to the ministerial office, and may be performed by an elder or pastor (*Art. Smalcald*, p. 352); though, for the sake of order, it is usually administered by a superintendent or prelate in the presence of other pastors (see Gerhard, *Loc. Theoll.*, xii. 145, 159). In administering it, prayer and imposition of hands are used, the latter being regarded not in any sense as a sacramental symbol, but merely as a venerable usage, which has descended from apostolic times, and as useful for admonition (Gerhard, xii. 163). "We have followed this usage," says Reinhard (*Dogmatik*, p. 635), "not from superstition, as if by it some special sanctity were imparted, but simply that the party who undertakes the office of a public teacher may be admonished of the importance of his office, and may be indicated to the congregation as one in whom it may repose trust."

The doctrine of the *Reformed Church* respecting ordination does not essentially differ from that of the Lutheran. Persons duly appointed, whether by the choice of the people or by a patron, and found duly qualified, after examination by the pastors of the district, are publicly ordained by prayer and the laying on of hands. According to Calvin himself, "though there is no direct injunction of the imposition of hands, yet the rite having always been observed in apostolic times, deserves to be retained, and is useful as tending to commend to the people the dignity of the ministry, and to remind him who is ordained that he is not his own, but is bound to the service of God and the church." He is doubtful, however, whether a plurality of pastors be indispensable for the ordaining of a minister, and he adduces the case of Timothy, as one in which ordination was administered by the Apostle alone (1 Tim. i. 5); the statement in 2 Tim. iv. 14 being understood by him "non quasi Paulus de seniorum collegio loquatur, sed . . . quasi diceret, Fac ut gratia, quam per manuum impositionem recepisti, quum te presbyterum crearem, non sit irrita." (*Inst.*, lib. iv. c. 3, § 16.)

According to the *Presbyterians*, ordination is "the solemn setting apart to some public church office," and is to be performed, with authority of the Presbytery, by prayer and imposition of hands. The doctrine of the Church of Scotland, as expounded by Dr Hill, is, that "every one who is ordained by the laying on of the hands of the office-bearers of the church becomes a minister of the church universal. He is invested with that character, ... and by this investiture he receives authority to perform all the acts belonging to the character." The business of the church, he adds, "is to convey the powers [of the ministerial office] to those whom she finds qualified. By ordination they become ministers of the church universal;" and he carefully distinguishes between this and the election or appointment by which a man becomes the minister of a particular congregation; "this assignation of place being merely a matter of order, which is not essential to his character." (*Lectures in Divinity*, vol. ii., p. 439, 440, third edit.) In the United Presbyterian Church, this local assignation enters as an important element into the effect of ordination: the party is ordained "to the office of the holy ministry, and to the pastoral inspection of the congregation by whom he has been chosen and regularly called." (*Rules and Forms of Procedure*, &c., p. 47.) In administering ordination, a minister, who is either the existing moderator of the Presbytery, or one appointed to act as such for the occasion, presides; a sermon is preached, in some cases by the moderator, in others by some minister appointed by the Presbytery; certain questions are then put to the candidate, bearing on his religious belief, ecclesiastical relations, and official engagements; and on receiving satisfactory answers to these, the presiding minister engages in prayer, and by imposition of hands, in which all the members of the presbytery present join, ordains the candidate; after which the latter receives the right hand of fellowship from his brother ministers, and suitable addresses are delivered to minister and people on their respective duties.

Ordnance ‖ Ores.

By the *Independents*, or *Congregationalists*, strenuous objection is taken to the doctrine that ordination is the investing of a man with the character of a minister of the church universal. Such an "*individuum vagum*, or pastor at large," they hold to be "irregular and cross to the order of the gospel," being a pastor without a flock, an officer without an office, a ruler without subjects. (Hooker and Cotton's *Survey of Church Discipline*, part ii., chap. ii., p. 60; 4to. 1648.) They regard "ordination not as a designation to the work of the ministry (of which they find no examples in the New Testament), but as a solemn appointment to office in a Christian church" (Fuller, *Works*, v. 280); and, consequently, when a minister changes his place of service it would be according to their principles that he should be re-ordained in his new sphere. In practice, however, this latter course is not always followed; nor are all agreed as to the necessity of ordination even in the first instance. The views chiefly prevalent among English and Scottish Independents are expressed in the following article of the *Declaration of Faith, Church Order, and Discipline of the Congregational or Independent Dissenters*, issued in 1833:—"They believe that church-officers, whether bishops or deacons, should be chosen by the free voice of the church; but that their dedication to the duties of their office should take place with special prayer and by solemn designation, to which most of the churches add the imposition of hands by those already in office." The order usually adhered to in this service is as follows:—First, a sermon is preached, which is generally devoted to an exposition and defence of Congregational church polity; then certain questions are proposed to the candidate regarding his personal religious history, his views of divine truth, his motives for desiring the work of the ministry, and his intentions as to the actual discharge of the functions of the ministry in the sphere to which he has been called; the ordination prayer is then offered, usually by the minister who puts the questions, and, when imposition of hands is used, by all the ministers present uniting with him in this act; after which the ministers give to the newly ordained pastor the right hand of fellowship. Some minister of experience then gives the charge to the pastor, and another addresses the people on their respective duties; and the service concludes, as it began, with prayer and praise. By some it is held that the right of ordination rests with the officers of the individual church in which the party to be ordained is to officiate, and, in the absence of such, with the private members (Davidson, *Ecclesiastical Polity of the New Testament*, p. 241, ff.); but these extreme views are not generally entertained by Congregationalists. (W. L. A.)

ORDNANCE, a general name for all sorts of great guns used in war. (For the various officers of the Ordnance, see ARMY, and NAVY.)

ORES are the mineral bodies from which metals are extracted. Metals exist in ores,—(1.) In the metallic state, when they are either pure or combined with each other, as in the state of alloy; (2.) Combined with oxygen in the

Orebro ‖ Oregon.

state of an oxide; (3.) Combined with sulphur in the state of sulphuret; and (4.) With acids, forming salts. (See MINES AND MINING.)

ÖREBRO, a town of Sweden, capital of a län of the same name, stands near the western extremity of Lake Hielmar, 100 miles W. of Stockholm. The streets are wide and clean, and the houses neatly built of wood, painted of a red colour, with white doors and window-frames. In the principal church, which is a handsome edifice, there are numerous interesting monuments, and the grave of Engelbrecht Engelbrechtson, the Swedish patriot, killed in 1436. The town contains also a fine ancient castle, a town-hall, assembly-house, hospital, &c., and the old house is still to be seen where Gustavus Vasa and Charles IX. lived, and where Bernadotte was elected Crown Prince of Sweden in 1810. Manufactures of linen and woollen stuffs, waxcloth, hosiery, paper, and tobacco, are carried on here; and there is a large printing-house, where many of the best Swedish works are printed. A considerable trade is carried on with Stockholm through Lake Hielmar, the canal of Arboga, and Lake Mälar. Pop. 5807.

The län of Örebro is 98 miles in length from N. to S., and 57 in width at the broadest part, and has an area of 3250 square miles. It is hilly towards the north, and throughout the rest of its surface of an undulating nature. It abounds in lakes and rivers, and in the hilly region there are rich mines of iron and other minerals, and extensive forests, which furnish the principal articles of export from the län. Cattle of good breed are reared in the pasture-grounds. The principal crops are, rye, barley, oats, and potatoes. Pop. (1850) 137,660.

OREGON, a territory of the United States of North America, lies between N. Lat. 42. and 46. 18., W. Lon. 108. 44. and 124. 28.; and is bounded on the N. by the territory of Washington, from which it is separated by the Columbia River and the 46th parallel of latitude; E. by Nebraska, from which it is separated by the Rocky Mountains; S. by the territory of Utah and state of California; and W. by the Pacific. Its length from E. to W. is about 665 miles; breadth, 279 miles; area, 105,030 square miles. Besides the Rocky Mountains on the eastern frontier, Oregon is traversed by two other ranges having the same general direction from N. to S., and dividing the territory into three distinct regions. The most westerly of these is the Cascade Coast, or, as it is sometimes called, the President's Range, at a distance varying from 80 to 150 miles from the coast. It is very lofty, having many peaks from 12,000 to 14,000 feet above the sea, and quite continuous, except where it is interrupted by the Columbia at the north frontier of Oregon. This mountain chain extends beyond the limits of Oregon, from Russian America in the north to the peninsula of California in the south. It almost entirely cuts off the communication between the coast and the interior, as there are but few passes, and these are so beset with difficulties as to be almost impracticable. The highest point in these mountains is Mount Hood, 18,361 feet above the level of the sea. The Blue Mountains, though having the same general direction as the two ranges between which they stand, are more irregular and interrupted than either the Rocky Mountains or the Cascade range. They branch off from the Rocky Mountains in British America, stretch southwards through Washington and Oregon, and finally extend into the state of California, where they take the name of Sierra Nevada. They send off branches on the east to the Rocky Mountains, and on the west to the Cascade range. Of the three regions into which Oregon is divided by these mountain chains, that which lies between the Cascade range and the ocean is the only agricultural part of the country, and is watered by the Willamette, Umpqua, and Rogue rivers, all of which rise in the Cascade Mountains, and fall, the first into the Columbia, and the two others into the Pacific. Many branches and offsets from the main ridge diversify this country, and these are covered with forests of oak, pine, fir, spruce, ash, and other kinds of timber, with a thick undergrowth of hazels, briars, &c. There are also in this region many valleys and prairies, where the soil is rich and loamy, furnishing good land for cultivation, and excellent pasturage. The coast of Oregon, which is in general bold and steep, is rendered dangerous for navigation by the heavy surf which continually breaks against every part of it. Of the few promontories which diversify the uniformity of its outline, the most noteworthy are capes Lookout, Foulweather, and Blanco or Orford. There are no considerable inlets of the sea; and as the mouths of the small rivers here are generally obstructed by sand-bars thrown up by the violence of the waves, the harbours are few and insignificant. Those in the estuary of the Columbia, and that which lies at the mouth of the Umpqua, are the most important seaports of Oregon. The middle region of the territory, lying between the Cascade and the Blue Mountains, is of a different nature, and more suitable for pastoral than for agricultural purposes. The surface is undulating, and in general elevated about 1000 feet above the sea. With a large extent of barren and lonely deserts in the south, this region contains throughout a great part of its area fine pasture-grounds, and is watered by the Fall River, an affluent of the Columbia from the south, and by several smaller streams. The most easterly region of the territory, extending from the Blue to the Rocky Mountains, is for the most part barren and rocky, so as to be quite incapable of improvement either for agricultural or pastoral pursuits, except in the immediate vicinity of the rivers. In some parts the surface is covered with wood, and it is broken by numerous mountain ridges and isolated hills. The Salmon River Mountains traverse this country from E. to W.; and the principal rivers are the Salmon River, to the north of this range; and on the south the Snake River, into which the former flows, and which discharges their united waters into the Columbia. In the Rocky Mountains, within the territory of Oregon, there is but one pass, the South Pass, at the extreme S.E., 7489 feet in elevation. This forms the great thoroughfare to Utah and California from the east, and by this path the stream of emigration enters these countries. In geological character, the whole country between the Cascade and the Rocky Mountains is of primitive formation. Traces of volcanic agency occur in many places, and in some parts there are extensive beds of lava, in which the rivers have worn channels for themselves. In the western region formations of later eras are general, but in the southern part even of this region primitive rocks occur. Of the mineral wealth of the territory comparatively little is yet known; but gold has been found in the Cascade range and in the rivers that descend from it. Indeed the whole country to the west of the Blue Mountains is believed to abound in this metal. The valley of the Willamette is also rich in coal. The western region of Oregon enjoys a mild and temperate climate. The summers are warm and dry, and the winters neither long nor severe, the difference between the extremes of heat and cold not being so great as in places of the same latitude on the American shores of the Atlantic. A considerable amount of rain falls, chiefly in winter; but the snow only lies for a short time. At Oregon city, not far south of the Columbia, the mean temperature of the whole year is 54°; of spring, 54°; of summer, 70°; of autumn, 54½°; and of winter, 40°. In the central region the climate is colder and more variable, but the atmosphere is healthy and bracing. In the eastern region the climate is very variable, and hardly any rain or snow falls. The forests of Oregon abound in many kinds of wild animals,—as elks, deer, antelopes, bears, wolves, foxes, beavers, &c. The eastern region of Oregon contains many buffaloes.

Oregon.

Oregon.

Fur-bearing animals, which were formerly very abundant, are now falling off in numbers, and constitute no longer a profitable pursuit. Ducks, geese, and other waterfowl are extremely numerous in spring and autumn on the rivers and lakes. In all these, as well as in the sea off the coasts, fish of many kinds are found; such as salmon, sturgeon, cod, carp, &c., as well as crabs, oysters, mussels, and other shell-fish. The only part of Oregon that has yet been settled and cultivated is that which lies to the west of the Cascade Mountains. In 1850 the territory contained (exclusive of the counties of Clark and Lewis, which then belonged to Oregon, but have since been formed into the territory of Washington), 115,691 acres of cultivated, and 247,212 of uncultivated land in farms. The whole value of the farms was in that year L.492,927; and that of the farming implements and machinery L.34,112. There were produced in Oregon in the year ending June 1, 1850, 200,148 bushels of wheat, 2913 of maize, 54,524 of oats, 29,536 lb. of wool, 3822 bushels of pease and beans, 58,429 of potatoes, L.15,964 worth of market-garden produce, 209,564 lb. of butter, and 35,930 lb. of cheese. Of live stock there were in the territory in the same year 6679 horses, 414 asses and mules, 34,334 horned cattle, 4024 sheep, and 28,729 swine; the whole being valued at L.350,651. The only mining operation carried on in Oregon is gold-digging, which is pursued in the valleys in the south-west of the territory. Nor are the manufactures of the country of much importance, being confined to such articles as are required to supply the wants of a scattered agricultural people. Some trade, however, is carried on in the exportation of timber, leather, beef, pork, salmon, onions, potatoes, butter, cheese, &c. A line of steamers plies between San Francisco and the Columbia. The exports of Oregon for the year ending June 30, 1856, amounted in value to L.1296; and the imports to L.565. According to the constitution of Oregon, promulgated in 1848, the executive power is in the hands of a governor, appointed for a period of four years by the president of the United States, and removable at will by the same authority. The legislature consists of a council of 9 members, and a house of representatives of not less than 18, or more than 30; both elected by the people, the former for three years, and the latter for one. The right of voting and of eligibility as a member of the legislative body belongs to every white male of full age in the territory who is either a citizen of the United States, or declares upon oath his intention to become such; but the legislature may introduce new limitations in the franchise. By a vote of the people in June 1857 a convention was appointed to prepare a constitution for Oregon as a state, which was to be submitted to the people for ratification. At the same time the questions connected with slavery, as regards Oregon, were to be decided by popular vote; and if the constitution be ratified, provision is made for the election of a state government and representatives in Congress, June 7, 1858. The number of churches in Oregon, according to the census of 1850, was eight, having an aggregate accommodation for 2633; and property amounting to L.15,315. Little progress has yet been made in education, as indeed little could have been expected from the scanty population; but certain lands have been allotted for the endowment of a university; and of the public land, two sections in each township are reserved for educational purposes, an amount which will yield a large sum, being double what is allowed in the other new states. There were in Oregon in 1850, 29 academies and schools, with 44 teachers, and 898 pupils. In the same year the total number of adults in the territory unable to read and write was 156. Oregon is gradually rising to wealth and prosperity by the steady labour and industry of the inhabitants; while at the same time the means for the religious and intellectual advancement of the people are by no means neglected. The discovery of the coast of Oregon is an honour disputed by the British and Spanish nations; for it was visited by navigators from both countries in the sixteenth century. Ferrelo, a Spaniard, is said to have reached as far N. as Lat. 43. in 1547; while in 1579 Drake arrived at the 48th parallel. The estuary of the Columbia was first entered in 1792 by Captain Baker, an Englishman, and Captain Gray, an American; and on account of the priority of the entrance of the latter, the American government laid claim to the entire country watered by that river and its affluents. These conflicting pretensions gave rise to many serious and long-continued disputes between the three powers, which were finally settled only by the treaty of 1846, by which all the country south of N. Lat. 49. was ceded to the United States. The whole of this country was originally comprised in the territory of Oregon, but has since been divided into those of Oregon and Washington. Pop. (1850), exclusive of the present territory of Washington, 12,093; (1853), 33,324; (1857), estimated at 43,000.

Orel.

OREL, or ORLOV, a government of European Russia, lying between N. Lat. 51. 55. and 54., E. Long. 32. 40. and 38. 50., is bounded on the N. by the governments of Kaluga and Tula, E. by Tambov, S.E. by Voronetz, S. by Kursk, and W. by Tchernigov and Smolensk. Length from N.W. to S.E. 262 miles; breadth, varying from 28 to 112 miles; area, 18,258 square miles. Though elevated throughout, the surface is not broken by any mountains; only some chains of limestone hills, and heights along the river-banks, intersect the country, forming in some places deep and picturesque valleys. Nearly a third part of the government is covered with forests; but there are very few barren, heathy, or marshy tracts. The principal rivers are the Desna, a tributary of the Dnieper, which flows in a southerly direction across the west of Orel; the Oka, which flows through the centre and north of the government to join the Volga; and in the east the Sosna, an affluent of the Don, flowing N.E. There are also numerous smaller streams; but no lakes of any size. The soil is for the most part light and sandy, but well suited for all kinds of grain, which it produces in larger quantities than the wants of the inhabitants require. The climate of Orel is temperate and healthy. Agriculture is extensively carried on; all kinds of corn, hemp, flax, hops, and tobacco are grown. The extent of arable land in the government in 1849 was 5,608,392 acres; of meadow land, 918,274 acres; of wood, 2,599,206 acres; and of waste land, 2,239,696 acres. Gardening is carried on here to a large extent, and is better understood than in any other part of Russia; and fruits and vegetables are grown in large quantities. The trees most common in Orel are, limes, birches, alders, aspens, firs, elms, &c. Foxes and hares are abundant, and are frequently hunted. The rearing of cattle is well attended to in Orel. Of horses, which are of excellent breed, suited either for riding or for farm labour, the government contained in 1849, 590,955; of horned cattle, 368,824; of sheep, 1,038,721; of swine, 535,760; and of goats, 2171. Great numbers of bees are kept. Many valuable minerals are obtained here, such as iron, lime, mill-stones, grindstones, alabaster, &c. Few manufactures are carried on, as the peasants make for themselves those articles that they need. There were, however, in 1848 thirteen beet-root sugar manufactories, using 4435 tons of beet-root, and producing 2660 cwt. of sugar. Orel contains also a few other manufactories, where coarse woollen and linen stuffs, cordage, earthenware, soap, iron, &c., are produced. The trade is considerable, consisting in the exportation of grain, flour, hemp, spirits, honey, iron, hardware, and other articles. The imports from foreign countries all enter the government by way of Moscow. The inhabitants are frugal and industrious; but ignorant, and strongly prejudiced in

Orel ‖ Orenburg.

favour of old customs. The majority belong to the Greek Church; but there are about 650 Roman Catholics, and a few Protestants and Mohammedans. Education is in a very low state, though nominally under the management of the university of Moscow. Pop. 1,406,571.

OREL, the capital of the above government, stands at the junction of the Oka and the Orlik, 201 miles S.S.W. of Moscow. It is defended by an ancient fort; and has a very gloomy appearance, with narrow, ill-paved streets, and wooden houses. There are here fine public gardens, well laid out, and commanding an extensive view. The town was destroyed by fire in 1848, when more than 1237 houses, four bridges, and many granaries full of corn and provisions, were burnt. On that occasion the emperor distributed 50,000 rubles (L.7812) among the poorer people who suffered by this calamity. Orel contains numerous churches, several schools, and benevolent institutions. Manufactures of linen, leather, tallow, and other articles, are carried on; but the place is chiefly important for its trade, which is much facilitated by the advantageous position of the town, in the middle of a fertile country, and on a navigable river. It is a great central mart for the commerce between the Black Sea, the Baltic, and the Caspian. Corn, wine, provisions, cattle, hemp, tallow, leather, &c., are the articles of trade; and both Moscow and St Petersburg are supplied with corn and provisions to a large extent from Orel. Several annual fairs are held here, which are well attended. Pop. (1851) 25,630.

ORELLANA, FRANCISCO, the first European navigator of the River Amazon, was born at Truxillo in Spain about the beginning of the sixteenth century. While still a young man, he emigrated to the recently-discovered continent of America. His services were first employed by Francisco Pizarro in the successful expedition against Peru in 1531. He then joined a band of adventurers who, under the command of Gonzalez Pizarro, the brother of the Peruvian conqueror, were bent upon carrying European discovery into the interior of the continent. Starting from Quito, the capital of the republic of Escuador, the explorers with exceeding difficulty reached the course of the Napo, a tributary of the Marañon. Famine compelled them to stop. Through the energy and courage of Orellana a vessel was built, manned, and despatched down the river, under his command, to procure provisions. No sooner had he sailed away, than he formed the bold resolution of continuing the expedition on his own responsibility, and with the force now under his command. At length, in August 1541, the solitary crew, after they had measured a continent, and encountered the most unheard-of privations, came in sight of the open ocean. Orellana took the first opportunity of hastening to Spain to recount his adventures. The government believed his accounts of the tribe of female warriors that dwelt by the river he had discovered, and of the temples roofed with gold that he had seen. Accordingly the river was called the Amazon; and a commission was given to the discoverer to establish colonies in this new "El Dorado." Orellana returned, only to die, in 1549.

ORENBURG, a government of Russia, partly in Europe and partly in Asia, lying between N. Lat. 47. and 56., E. Long. 50. 20. and 64. 20.; and bounded on the N. by the government of Perm, N.W. by Viatka, W. by Kasan and Samara, S.W. by Astrakhan, S. by the Caspian, S.E. and E. by the Kirghiz steppes, and N.E. by Tomsk and Tobolsk. Its length from N.W. to S.E. is 800 miles; breadth about 450 miles; area, exclusive of the Kirghiz steppes, 122,122 square miles. The surface of the country has a very different aspect in different parts. The Ural Mountains traverse it in an irregular line, but generally from N. to S., dividing the area into two very unequal portions—that to the W. being much the larger. The southern portion, which is occupied by the Ural Cossacks, consists of a barren treeless steppe; but farther to the north, on the Asiatic side of the Ural chain, there is a large plain, with numerous swamps, morasses, and small lakes. To the west of the mountains, again, the country is undulating; with varied and picturesque scenery. The formation of the Ural Mountains at the base is granite; but above this there are quartz and calcareous rocks. Many large caverns occur in these mountains. Gold is found in the chain, and constitutes one of the chief sources of mineral wealth to the government. The country west of the mountains is watered by the affluents of the Caspian Sea; of which the principal is the Ural, flowing southwards from the mountains, and receiving in this government the Samara and other tributaries. This river forms part of the boundary between Europe and Asia. The western portion of Orenburg is watered by the Biela, Samara, and other streams which flow into the Volga, and thus into the Caspian. The rivers to the east of the Ural range are the Tobol, Abuga, Oui, and Mijas, which flow northwards to the Arctic Ocean. The greater part of the surface has a fertile soil, especially in the N.W.; a large part of the government is covered with thick forests; and a still larger portion consists of natural pasture-grounds, on which large herds and flocks wander. The climate is excessive in heat and cold, especially to the east of the Ural Mountains, where it is more rigorous than in the west. The southern steppes are very hot in summer, and these regions are afflicted by excessive drought and swarms of locusts. Agriculture is in a flourishing state, on account of the richness of the soil. The arable land amounted in 1849 to 5,780,326 acres, the meadow land to 10,851,906 acres, the wood to 29,612,089 acres, and the waste land to 48,451,163 acres. The amount of agricultural produce in the government in the same year was 38,112,219 bushels of corn, and 1,459,259 of potatoes. The principal crops raised are rye, barley, oats, buck-wheat, and millet. The inhabitants possess great numbers of horses, cattle, and sheep, in which the chief wealth of Orenburg consists. There were here in 1849, 2,075,220 horses, 1,089,859 horned-cattle, 2,321,934 sheep, and 207,143 swine. Besides the gold of the Urals, other minerals, such as copper, iron, salt, &c., are found, and the working of these employs a large number of hands. Great quantities of fish are obtained in the River Ural. Manufactures are not carried on to any very great extent, being chiefly confined to smelting, founding, and other operations connected with the mines. There are also, however, numerous tanneries, distilleries, potash-factories, and a manufactory of arms. The women of the province show great skill in weaving and dyeing; and they make worsted shawls and similar articles, like those that are made in the Orkney and Shetland islands. The number of manufactories in Orenburg in 1849 was 244, employing 17,104 hands. Of these there were 63 tanneries, 61 potash-factories, 43 tallow-melting houses, 40 tile-kilns, 17 smelting-houses and foundries; besides other establishments. An extensive commerce is carried on in the government, with the wandering tribes, the Kirghizes, and the people of Bokhara. Horses, cattle, furs, &c., are obtained from the nomad tribes in exchange for manufactured articles, brass, copper, iron, &c.; and silks, cotton, shawls, indigo, tea, and other goods are brought to Orenburg by the caravans from Bokhara. Mineral produce is exported from Orenburg to the other parts of European Russia; and especially to the shores of the Baltic. The Kirghizes and Cossacks in Orenburg are not subject to the civil government; but are under a military governor, whose principal duty is to superintend the line of forts by which the frontier towards Turkestan is secured. These extend in a line at the distance of 3 miles from each other from the River Tobol to the Caspian. Besides adherents

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of the Greek church, there are in the government numerous Roman Catholics, Protestants, Mohammedans, and Pagans. Exclusive of the country inhabited by the Cossacks, Orenburg is divided into nine circles, and contained, in 1851, 1,712,728 inhabitants, including 242,661 Cossacks.

ORENBURG, a town, formerly the capital of the above government, stands on the Ural, 465 miles N.E. of Astrakhan, and 657 S.W. of Tobolsk. It is of an oval form, with wide and regular, but ill-paved streets; and presents an active and agreeable appearance. It is surrounded by fortifications; and the most of the houses are of wood, though a few are built of stone. It has a cathedral and other Greek churches, Roman Catholic and Protestant places of worship, and two mosques. The town has also two bazaars, a European and an Asiatic, each on the side of the river belonging to their respective countries. The former contains 180, and the latter 492 shops. Manufactures of woollen cloth, leather, soap, and tallow, are carried on here. Orenburg is the chief emporium for the Russian trade with Central Asia. Caravans arrive here yearly from Bokhara, with jewels, gold, silk, cotton, &c.; and from the Kirghizes with cattle and hides; while many merchants from China and India bring hither their goods. It is the principal military station on the Kirghiz frontier. Pop. 16,000.

ORENSE. See GALICIA.

ORESTES, the hero of several old Greek tragedies, was the only son of Agamemnon and Clytemnestra. The events of his history appear under various modifications in the *Chœphoræ* and *Eumenides* of *Æschylus*, in the *Electra* of Sophocles, and in the *Orestes* and *Iphigenia in Tauris* of Euripides. The following account, however, contains the essential incidents of the story. On the murder of Agamemnon by Clytemnestra and her paramour Ægisthus, the boy Orestes was saved by his sister Electra, and was entrusted to the protection of his uncle Strophius, King of Phocis. There he was educated, and formed a friendship with his cousin Pylades, which became proverbial. At the end of eight years a response of the Delphic oracle sent him home to Mycenæ to revenge his father's death. Gaining admittance into the palace by stratagem, he slew Clytemnestra and Ægisthus with his own hand, and thus entailed upon himself the severest woes. The Eumenides immediately appeared, and in punishment for the murder of his mother, remorselessly hunted him from country to country. They had tortured him into frenzy when he found himself at Delphi. The oracle there, by informing him that he would free himself from his dread persecutors by bringing away the statue of Diana from Tauris in Scythia, only sent him into new troubles. He and his friend Pylades were on the point of being sacrificed to Diana, according to the custom of the country, when his sister Iphigenia, the priestess of the goddess, discovering them, assisted them to escape, and gave them the object of their visit. The sorrows of Orestes were thus ended, and the remainder of his life was prosperous. The hand of Hermione, the daughter of Menelaus and widow of Neoptolemus, was conferred upon him; the death of his father-in-law left him in possession of his paternal kingdom of Mycenæ; the Lacedæmonians voluntarily became his subjects; and the Arcadians and Phocians became his allies. He died at an advanced age in Arcadia, in consequence of a bite from a snake. His bones were afterwards removed from Tegea to Sparta.

ORFAH, or URFAH (anc. *Edessa*), a town of Asiatic Turkey, in the pashalic of Diarbekir, and 80 miles S.W. of the town of that name. It is built on the lower part of two hills, and in an intervening valley; and is surrounded by a lofty and strong wall, about 7 miles in circuit. The streets are narrow, but clean and well paved; and there are numerous bazaars, and some good caravansaries. Among its numerous mosques there is one very splendid building, with several medresses or colleges attached to it. Coarse woollen and cotton stuffs are manufactured here; the corn grown in the vicinity is exported to Syria; and manufactured goods are imported by way of Aleppo from Great Britain. Pop. about 30,000.

Orfila.

ORFILA, MATHIEU-JOSEPH-BONAVENTURE, the founder of modern toxicology, and one of the most eminent of the French school of medicine during its brightest period, was by birth a Spaniard, and native of Minorca. An island merchant's son looked naturally first to the sea for a profession; but a voyage at the age of fifteen to Sardinia, Sicily, and Egypt, did not prove satisfactory. He next took to medicine, which he studied at the universities of Valencia and Barcelona with so great applause, that the local government of the latter city granted him a pension, to enable him to follow his studies at Madrid and Paris, preparatory to appointing him professor. He had scarcely settled for that purpose in Paris, when the outbreak of the Spanish war, in 1807, threatened destruction to his prospects. But he had the good fortune to find a parent in a merchant uncle at Marseilles, and a patron in the good and great Vauquelin the chemist, who braved the wrath of Napoleon against the Spaniards, claimed him as his pupil, guaranteed his conduct, and saved him from expulsion from Paris. Four years afterwards, he graduated in his twenty-fourth year, and immediately became a private lecturer on chemistry in the French capital. The peace of 1814 re-opened to him his native country, to which he considered himself bound to offer his services. Barcelona, however, impoverished by more than its own share of the miseries and devastation of war, was obliged to decline his offer. The talent and energy even of an Orfila could scarcely have withstood the deadening influence of Spanish rule in the days of Ferdinand VII. So apparently thought Orfila himself. For, when invited at a later period by that monarch to fill the vacant chemical chair of Proust at Madrid, he resolved to adhere to France, which became the land of his adoption by letters of naturalization. From that period he had a long career of distinction and unbroken prosperity. In 1819 he was appointed professor of medical jurisprudence, and four years later succeeded his aged patron, Vauquelin, as professor of chemistry in the faculty of medicine at Paris. In 1830 he was nominated dean of that faculty, a high medical honour in France. Under the Orleans' dynasty, honours were lavishly showered upon him; for he became successively member of the Council of Education of France, member of the General Council of the Department of the Seine, and commander of the Legion of Honour. But the republic of 1848 put an end to these adventitious distinctions, and reduced him to his simple professorship. His fame and happiness would have prospered better had he never aimed higher; for as a man in authority, he was eminently unpopular; and as a man of business, he was of necessity withdrawn in some measure from his proper pursuits as a cultivator of science. Chagrin at the treatment he experienced at the hands of the governments which succeeded Louis Philippe is supposed to have shortened his life. He died, after a short illness, in March 1853, in his sixty-sixth year, and in the full possession of his faculties and reputation. Only the evening before his death, he delivered a lecture with his usual animation; and a few days previously, he read a scientific paper before the Academy of Medicine.

Orfila's chief publications are four in number,—on General Toxicology; on Medical Jurisprudence; a treatise on Chemistry; and a treatise on Medico-legal Exhumations. But the medical journals team with valuable papers from his pen, chiefly on subjects connected with medical jurisprudence. His fame will ever rest mainly on his *Traité de Toxicologie Générale*, first published in 1814,

Orford || Organ.

when he was only in his twenty-seventh year. It is a vast mine of experimental observation on the symptoms of poisoning of all kinds; on the appearances which poisons leave in the dead body; on their physiological action; and on the means of detecting them. When one rises from a perusal of the earliest edition of that work, and considers how vast a proportion of it was at the time entirely new, it is not easy to say whether it is with greater wonder at the immense mass of information he so quickly collected, and, indeed, called into existence, or at the deplorable condition in which toxicology, especially in its relations to the law, must have stood before his researches. Few branches of science, so important in their bearings on every-day life, and so difficult of investigation, can be said to have been created, and raised at once to a state of high advancement by the labours of a single man.

Orfila was superb as a lecturer. Possessed of a diction and method eminently lucid, a magnificent voice nicely toned by a musical ear and practice (it is said he was so admirable a vocalist, that he might have made his fortune as a *baritone*); discussing a subject of novel and intense interest, and of his own creation; and with an audience of a thousand pupils before him, the most distant of whom he reached with conversational facility; nothing could be more attractive than his lectures on medical jurisprudence, as the writer heard them in 1821. In his frequent appearances as a witness on great criminal trials, he was no less conspicuous for the perfection of his preliminary inquiries, the luminous delivery of his statements in evidence, and his unflinching steadiness under cross-examination. Woe to the criminal whose guilt depended on the ability of Orfila to prove it!

The usage he received in his latter years from the ruling dynasty of France did not take away from his attachment to the medical school of Paris, the scene and source of all his triumphs. In his will he left a fund of no less than 120,000 francs (L.5000), to establish prizes in the Academy of Medicine and the School of Pharmacy. According to the fashion of France, in bidding adieu to her great men in science, his funeral was an ovation; and no fewer than six orations were pronounced over his grave in name of various scientific and professional bodies. (R. C.)

ORFORD, a decayed municipal borough and market-town of England, county of Suffolk, at the confluence of the Alde and the Ore, 16 miles E. by N. of Ipswich, and 80 N.E. of London. The church is a fine old building, with a square embattled tower; and there is also here a town-hall, and the remains of an ancient Norman castle. The inhabitants support themselves chiefly by the oyster fisheries in the neighbouring rivers. On account of the sea having receded from the land, the harbour of Orford has been destroyed; and this has led .o the decay of the place. Pop. 1045.

ORGAN, by far the most noble and imposing of all musica. instruments. It is quite inconsistent with the design and limits of this work for us to enter into all the details of the nature and structure of the organ. They would fill a volume, and require many illustrative plates. We shall, however, endeavour to give such a general idea of the nature of the instrument as may satisfy those readers who are not professionally interested in the subject; and we assure them that their own inspection of the mechanism of an organ (which is easily attained in every large town) will afford them more clear and satisfactory knowledge than hundreds of pages written in explanation of its construction. For minute details, we refer to *L'Art du Facteur d'Orgues*, by F. Bedos de Celles, published at Paris in 1766 and 1778, in folio, with 137 plates. This is considered, even now, as the best and most complete work on organ-building. It is a pity we have none such in the English language. See also the Abbé Vogler's German works upon organ-building, and G. Serassi's *Lettere sugli Organi*, printed at Bergamo in 1816; together with Reports of the French Institute upon M. Grenié's improvements on the organ. We suspect that the general want of improvement in organ-building in Great Britain may be traced to the absence of such works, and some others, in our own language, for the instruction of our organ-builders. This may also explain, in some degree, why almost all the best organs in England were constructed by foreigners. Recently, however, we are happy to perceive a spirit of emulation arising amongst our native organ-builders; and we have little doubt that the ingenuity and superior workmanship of British artisans will soon enable us to vie with, or excel, the best organ-builders of the Continent. But, to do this, we must cast aside all national prejudices as to organs, &c. and meet foreigners upon a fair and liberal ground of competition. Organ.

The earlier history of the organ is extremely obscure. A small and imperfect instrument, somewhat on the principle of the organ, may have been known to the ancients; but surely nothing like our great church-organ. We read of ancient *hydraulic* and *pneumatic* organs; but such distinction is so far erroneous, inasmuch as organ-pipes could not be made to sound by having *water* forced through them. The water must have been a moving power only, to impel the *wind* into the pipes. It would seem that the Greek and Latin terms ὄργανον and *organum*, translated by the English word *organ*, originally signified an instrument or machine of any kind, and were afterwards applied to musical instruments of all kinds. "*Organa dicuntur omnia instrumenta musicorum*," says St Augustin. Still later, according to St Isidore, these names, ὄργανον and *organum*, were applied to none but wind-instruments. In modern times the term organ, in a musical sense, came to signify only the instrument which we now know under that name. The passage in Eginhard's Annals which has been interpreted the sending of *an organ* by Constantine Copronymus to King Pepin in the year 757, may more probably mean "*various musical instruments*," since the words are, "*Constantinus Imperator Pipini regi multa misit munera, interque et organa*," &c. A writer of the sixteenth century has ventured to describe the supposed *organ* sent to King Pepin; and, by force of imagination, makes it out to have been a grand organ with pedals. In Luitprand's History (book vi. c. 2) there is a curious passage regarding an instrument sent to the Emperor Constantine in 950:— "Erat Regia ornata sumtuosissime, ibi ænea inaurata arbor ante ipsius imperatoris solium effulgebat, expansis magnum in modum ramis aereis atque inauratis; in his frequentissimæ variarum specierum aves arte confictæ, quarum singulæ speciei proprias voces cantusque emittebant, incredibili arte." In the second volume of Gerbert (*De Cantu et Musica Sacra*, plate xxviii.) will be found a representation of a tree of this kind with birds upon it. The Chronicle of Albericus adds to the singing of the birds before Constantine, "the roaring of enormous gilded artificial lions." (See Gerbert, vol. ii. p. 151.) That such birds can be made, is certain from Maillardet's beautiful little artificial bird, which started up out of a gold snuff-box, fluttered its wings, and sang with a pipe so clear and loud as to fill a large room. It would appear that, in the rude instruments called organs in the eleventh and twelfth centuries, the pipes were disposed in such a manner that every sound in its finger-key compass caused the fifth and the octave of that sound to be heard above it. Such a succession of fifths and octaves was called "organum," no doubt *par excellence*. From this and the old and extraordinary specimens of *Biscantus*, or *Discantus*, given by Gerbert and others, and alluded to in our article MUSIC (page 623), we are inclined to believe that the modern mixture-stops of the organ have originated. We leave the consi-

Organ. deration of the ancient organs to antiquaries, and now proceed to the modern organ, which seems to have assumed something of its present form in the fifteenth century.

The mechanism of the modern organ has been much improved at different times by different builders. The family of the Antegnati, of Brescia, were amongst the earliest famous organ-builders in Italy in the fifteenth and sixteenth centuries. In the eighteenth century there were in Italy many celebrated organ-builders, amongst whom Serassi of Bergamo, and Callido of Venice, each constructed upwards of three hundred organs.

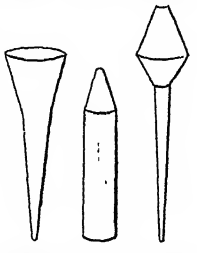
Most of our readers probably know already that the great organ is a complex wind-instrument, consisting of a great number of pipes of different sizes, formed of wood and of different kinds of metal, some of which are flute-pipes or mouth-pipes, and others reed-pipes; whilst all of these are made to sound by means of compressed air applied to them through certain channels, by bellows worked either by human force or by mechanism. There are different kinds of organs, from the Lilliputian bird-organ up to the great church-organ. We pass over the minor ones, including the chamber-organs and the smaller chapel-organs, and proceed to the great church-organ. We need not describe its front, nor the case in which its mechanism is contained. The great church-organ has usually three rows of finger-keys, placed above each other like steps. In some of the largest organs there are four, or even five such rows of keys. Besides these, there are rows of pedals, or foot-keys, which act upon the larger pipes of the organ. The bellows communicate, by a wind-trunk, with wind-chests, or reservoirs of air, whence the wind is distributed to the various pipes of the organ when the finger-keys or the foot-keys (pedals) are pressed down. Attached to the upper part of each wind-chest is a sound-board, as it is rather improperly called. This sound-board consists of two parts, an upper and an under board, the latter of which is much thicker than the other. Both of these are formed of planks of wood laid horizontally side by side, and accurately joined together at their edges. In the under side of the lower board several rectangular grooves or channels are cut parallel to each other, and carried along nearly the whole length of the board, and as far as there are stops in the organ. In these channels are fixed bars of wood, so as to render each channel or *partition* completely separate from every other. In the upper side of this board are cut a number of other rectangular channels or grooves running across the board, and at right angles with the under grooves. Into these upper grooves are exactly fitted wooden sliders, or registers, which run the whole length of the grooves. These sliders can be drawn out so far or pushed in at pleasure, by a mechanism attached to the draw-stops that are placed on the right and left in front of the organ. Holes corresponding with the number or rows of organ-pipes placed above the sound-board, are pierced through the latter into the above-mentioned channels, and also through the sliders or registers, in such a manner that when the latter are drawn out, their holes correspond with those of the sound-board, and allow the air from the wind-chest to pass through them and through the other holes in the sound-board; whilst, on the contrary, when the sliders are pushed in, they completely prevent any air from passing from the wind-chest to the pipes above the sound-board. Above all, and corresponding with the upper holes of the sound-board, are placed the pipes, fitted in by their conical feet to what are called the stock-boards. There are rows of thin boards, called racks, which are sustained by pillars of wood, and which receive the upper part of the feet of the pipes in holes made for the purpose. Opening into the wind-chest, and fixed upon the under side of the sound-board, are spring-valves, which are connected, by a particular mechanism, with the finger-keys and pedals; and which, when the sliders are drawn out, and the keys and Organ. pedals pressed down, are made to open, and so to admit the air from the wind-chest into the channels or partitions belonging to the different rows of pipes constituting the various stops of the organ. The pedals and the finger-keys communicate with these spring-valves by means of an apparatus of trackers, cranks, and rollers, acting upon pull-down wires that pass through the bottom of the wind-chest, and are attached to these valves. The draw-stop movement, by which the sliders are drawn out or pushed in, consists of a similar mechanism. In some organs these sliders are superseded by another contrivance. Thus, in what are called by the Italians *somieri a vento*, the opening of a given stop or register is not effected by drawing out a wooden slider, so as to make its apertures correspond with those in the sound-board; but by pulling open, all at once, in the channels of the sound-board, as many small valves as there are pipes to that given stop. These small valves are made to open by pulling out a draw-stop, and to shut by pushing it in again. They are considered to have many advantages over the ordinary slider, as being more durable, and less subject to the influence of changes of the weather.

A stop is called simple if it consists of one row of pipes, and compound if it consists of more than one row. As to the different rows of finger-keys, each communicates with what is really a separate organ, or collection of pipes, with its peculiar wind-trunk, wind-chest, sound-board, &c. These different organs are generally three, and are called the great organ, the choir-organ, and the swell-organ. The middle row of keys is connected with the great organ, the lower with the choir-organ, and the upper with the swell-organ. The swell-organ has its pipes enclosed in a wooden box furnished with a sliding door, or a hinged door, which is gradually opened or shut by mechanism moved by the performer's foot applied to a pedal. All these different organs, constituting the great church-organ, are supplied with air by the same bellows, and by suitable wind-trunks connected with the bellows. The bellows now generally used are horizontal ones, instead of the old ones resembling blacksmiths' bellows. For some improvements in the sound-board and its appurtenances, see Serassi's *Lettere sugli Organi*.

We have already mentioned, that the pipes of an organ generally consist of mouth-pipes and of reed-pipes. With regard to the mouth-pipes, their nature may be pretty well understood by any one acquainted with the upper part of the common English flute, or the flageolet. The reed-pipes are explained in a subsequent part of this article. What we have said regarding sonorous tubes in the article Music, pages 608, 613, 615, may assist the reader in understanding our notices of organ-pipes. Organ-pipes are either open, or stopped, or half-stopped. The stopped ones have a plug or tompion inserted into their upper end, and pushed down or pulled up to regulate the pitch. The half-stopped ones have a kind of chimney at the top. Some of the middle-sized ones are partly stopped, and have also on each side of the mouth a kind of ear of metal, by bending of which outwards or inwards, the pitch of the pipe may be regulated. The largest pipes are square ones of wood, and belong to the pedals. In some great organs, the largest open pipe is thirty-two feet in length. The other pipes are made of wood or of metal. It has been observed by organ-builders and others, that the quality of tone (*timbre*) of pipes depends much upon their proportions in length and width, the material of which they are made, &c.; and also upon the form of their open top, by which the wind escapes. We shall have occasion to notice this again, when describing some of Grenié's improvements. A reed-pipe, with a conical tube which has a bell-shaped end, as in fig. 1, gives the most brilliant sound. If the pipe

Organ. have a reversed conical top, as in fig. 2, the sound becomes dull. If two similar truncated cones placed base to base be fixed to the wider end of a long conical tube, as in fig. 3, a reed-pipe so formed will give fulness and strength to the sound. Theory affords no satisfactory explanation of these facts. The *timbre* of the stopped and of the half-stopped pipes is softer and duller than that of the open ones. Pipes of pure tin have long been known to possess a *timbre* more clear and penetrating than those made of tin mixed with lead. Some years ago, a Bohemian organ-builder made some of his pipes of zinc, which was said to answer better than even tin. No doubt various simple and compound metals, and various other substances that have not yet been used in the making of organ-pipes, might be employed with advantage to produce a still greater variety of *timbres* and effects; and for the same purpose, various modifications of the ordinary forms of pipes might also be employed.

Fig. 1. Fig. 2. Fig. 3.



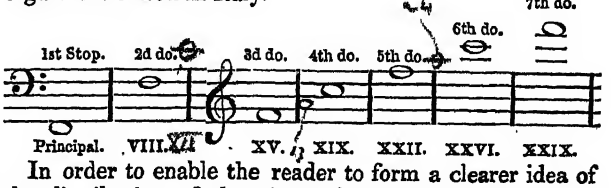
The pipes and stops of an organ differ in number and kind according to the size of the organ, the fancy of the builder, and the taste of the public. In some Dutch, German, and Italian organs, there seems to be a superfluity of stops. An immense organ at Weingarten, in Germany, is described as having sixty-six stops and 6666 pipes. The great organ at Haarlem contains sixty stops, and its largest pipe is thirty-two feet in length. For an enumeration of the stops of three of Silbermann's organs at Dresden, we refer to a Ramble among the Musicians of Germany, published at London in 1828 (pp. 193, 194, 195). One of the largest organs in Italy is said to be that built in 1733, by Azzolino della Ciaja, for the church of the Cavalieri di S. Stefano at Pisa. It is said to have four rows of finger-keys, and more than 100 stops. Another remarkable one is in the church of S. Alessandro, in Colonna, at Bergamo. It was built by Serassi in 1782, and has three rows of finger-keys, and about 100 stops. In it the first and second rows of keys serve for the great organ, and the second organ or choir-organ, built together in the same part of the church. By mechanism, which passes under ground, and extends to a distance of about 115 feet English, the third row of keys is connected with a third great organ placed in another part of the church, and directly opposite to the first great organ. Notwithstanding such a distance from the keys, the third organ obeys them as readily as the first one does. Its lowest pedal-pipes consist not only of mouth-pipes, but also of reed-pipes. The following is a brief description of another organ built by Serassi in 1796. "Two rows of finger-keys, the upper for the great organ, the *ripieno* of which consists of the following stops: Two principal soprani; two principal basses; octave, twelfth, fifteenth, twenty-second, twenty-sixth, twenty-ninth, two thirty-thirds, two thirty-sixths, and twelve deep bass stops belonging to the chromatic scale, with the octaves of these, all, however, governed by one register. The different stops belonging to the great organ are, the sesquialtera; two cornets; flute in octave; flute in twelfth; German-flute; vox humana; viola; bassoon; English horn; trumpets; trombones; cymbals; kettle-drums, and bass-drum, the last being managed by a pedal. The lower row of manuals or finger-keys serves for the second organ, or choir-organ. It has its *ripieno*, composed of principal, octave, fifteenth, nineteenth, twenty-second, twenty-sixth, and twenty-ninth; and has, besides, the stops of cornet, flute in octave, vox humana, and violoncello. By means of a pedal moved by the right foot, all the stops of the first organ can be opened or shut at once."

Of the different stops or registers of an organ, some derive their names from the instrument the tone of which they imitate, and some from the relation in pitch which they bear to the sounds of the diapason stop, as octave, twelfth, fifteenth, seventeenth, and so on. We subjoin a brief account of the most usual organ-stops. I. *Open diapason;* consists of metal mouth-pipes open at the upper end, and extends through the whole scale of the organ, as its name diapason imports. II. *Stopped diapason;* mouth-pipes generally of wood, and their pitch an octave below that of the open diapason. They are stopped at the upper end. III. *Double diapason;* wooden mouth-pipes, open at the upper end, and their pitch an octave lower than those of the open diapason. They are generally confined to the two lowest octaves of the organ's compass. In some of the largest organs, the gravest sound of these is rendered by an open pipe thirty-two feet in length. IV. *Principal;* metal mouth-pipes, the pitch of which is an octave above the open diapason. The *principal* is the first stop tuned; and then, from it, all the other stops. V. *Dulciana;* a metal mouth-pipe stop, tuned in unison with the open diapason. The sweetness of its tone originates in the length and narrowness of its pipes. VI. *Twelfth;* metal mouth-pipes tuned a twelfth above the open diapason. VII. *Fifteenth;* metal mouth-pipes tuned an octave above the principal. There are, in some organs, stops named *tierce* or *seventeenth, larigot* or *nineteenth, twenty-second, twenty-sixth, twenty-ninth, thirty-third,* &c., tuned respectively at these intervals above the open diapason. VIII. *Flute;* metal and wood mouth-pipes, in unison with the *principal.* IX. *Trumpet;* reed-pipes of metal, in unison with the open diapason. X. *Clarion* or octave trumpet-stop; metal reed-pipes tuned an octave higher than those of the trumpet stop. XI. *Bassoon;* reed-pipes, in unison, as far as their compass reaches, with pipes of the open diapason. XII. *Cremona,* or properly *krum-horn;* reed-pipes, in unison with the open diapason. XIII. *Oboe;* reed-pipes, in unison with the open diapason. XIV. *Vox humana;* reed-pipes, in unison with the open diapason, and intended to imitate the human voice, a function which in general they perform very unpleasingly.

Organ.

Amongst the *compound* stops used in organs are, I. The *sesquialtera,* consisting of four or five rows of open mouth-pipes at the intervals of seventeenth, nineteenth, twenty-second, twenty-fourth, or twenty-sixth, above the open diapason. II. The *cornet,* a stopped diapason, principal, twelfth, fifteenth, and seventeenth. III. *Mixture* or *furniture* stop, consists of several ranks of pipes nearly the same as those of the sesquialtera, but some of them of a higher pitch. Vogler denounces the *mixture-stops* as "*insignificant.*" We have sometimes heard a harsher term applied to them.

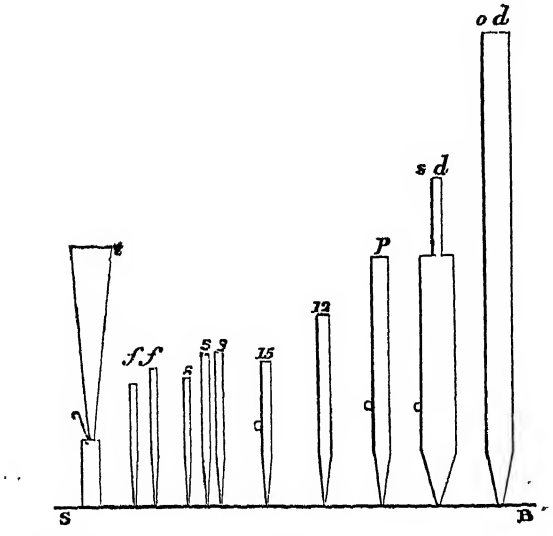
In Costanzo Antegnati's *Arte Organica* we find the following exposition of the series of registers or stops of the organs then used in Italy.



In order to enable the reader to form a clearer idea of the distribution of the pipes of an organ, we subjoin a sketch of a row of the usual pipes of the great organ (as contradistinguished from the choir and swell organs), and as these pipes stand upon and are inserted in the top of the sound-board. To simplify the diagram, the rack-board and pillars are not represented here. The letter *t* indicates the trumpet; *ff,* furniture; *sss,* sesquialter; 15, fifteenth; 12, twelfth; *p,* principal; *sd,* stopped diapason; *od,* open diapason; SB, the top of the sound-board. The other rows of pipes are, of course, to be imagined as placed behind those pipes here represented, and as extending, in their respective ranks, the whole length of each stop

Organ. or register, in lines at right angles with the line formed by the row of pipes shown in the diagram.

Fig. 4.



Not many years ago, M. Grenié, a French amateur of music, introduced several important improvements in the construction of reeds for organ-pipes. (See the Reports of the French Institute, &c.) His reed (AB in the annexed figure 5) was made of wood or copper, square-edged, and of the form of a parallelopipedon. [In order to show the difference between the construction of M. Grenié's reed and the common organ-pipe reed, we add a diagram of the latter, fig. 6.] The tongue was a thin plate of brass, of an even surface, and cut in a rectangular shape, so as to fit almost exactly the grooved face of the reed. A strong wire-spring *cc* kept down this tongue firmly upon the reed, at the proper length, so as to regulate the tongue's vibrations. The result of such a construction is, that when this reed, enclosed in its tube, is made to sound by air forced into the porte-vent DEF, by the aperture at F, the air thus introduced not obtaining admittance into the reed between the tongue and the sides of the reed-groove, impels the tongue into the latter. A little air having been thus admitted into the reed-channel, the elasticity of the tongue makes it resume its former position, so as again to exclude the air. The velocity which the tongue had acquired in its first vibration causes it, when returning, to pass beyond the limit of its former position, to which it is again brought back by the resistance of the air, and by its own elasticity, and whence the impulse of the current of air from the porte-vent again forces it into the reed-channel. The advantages of this construction are, that the tongue does not strike against the edges of the reed, as in the common reed-pipes, which thereby produce a harsh and uneven tone; and that its movements are smooth and regular, since it has nothing to encounter in its vibrations but the air itself. The sound of M. Grenié's reed-pipes is said to be, in the most acute as well as in the gravest of them, as sweet and pure as that of flute-pipes. M. Grenié adapted the degree of strength and rigidity of each tongue to the breadth of the reed-channel which it had to cover, so that the stream of air could never throw it into vibrations around its axis. The strength of the spring-wire also kept the length of the vibrating portion of the tongue unchanged; so that, whatever the force of the wind, the tone never altered its pitch. Only the intensity of the sound was affected by the greater or less impulse of air. By means of a pedal, the performer moved a spring-bellows, and, by thus regulating at pleasure the force of the wind, could obtain a *crescendo* and *diminuendo* in all the reed-pipes, as perfect as that of the human voice, or of instruments modified in their sounds by the lips and breath of the performer. Organ.

Fig. 5.

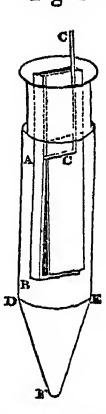
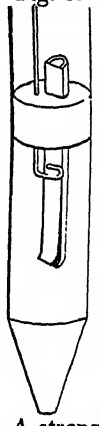
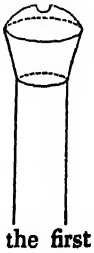


Fig. 6.



The air which causes these reeds to vibrate passes out through open pipes, bevelled off into a cone, and terminating in a hemisphere, fig. 7. This form is said to give roundness and strength to the tone.

Fig. 7.



M. Grenié, when constructing his reed-pipes, was for a long time checked by a very curious phenomenon. He was at first occupied with the gravest octave of which the sound C is in unison with an open flute-pipe of eight feet; and had constructed a certain number of pipes, in giving wind to all his reeds by pipes of the same length, fig. 8. But when he had reached the first notes of the tenor compass, still continuing to construct his porte-vents in the same manner, the reed would not sound at all. He in vain increased and diminished the wind, in vain lengthened and shortened the tongue; the reed remained mute, or produced only very bad sounds. At last, after many attempts, M. Grenié thought that the length of the pipe which conducts the wind to the reed might have some unknown influence upon its vibration. He therefore substituted for his fixed tubes two pipes, of which the one was made to slide within the other, so that he could gradually vary the whole length. He tried this change of length until the reed produced a clear, pure, and sustained sound. He found also, that in order to obtain the tenor sounds in all their fulness, it was necessary to make the porte-vent much longer than for the sound immediately preceding, and this length always went on diminishing for the most acute octaves, as is represented by fig. 9. Then the tops

Fig. 8.

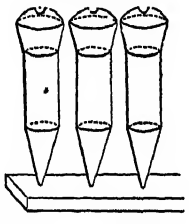
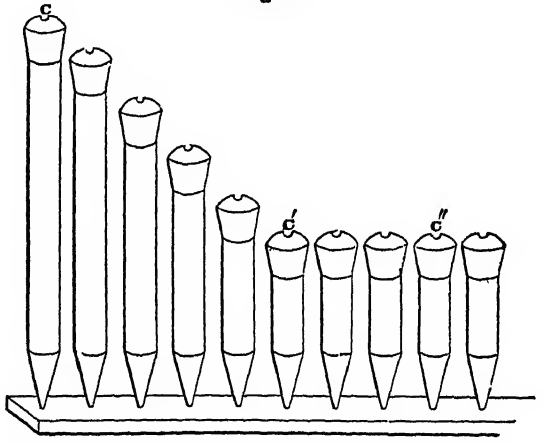


Fig. 9.



of the pipes formed the curve C C′ C″. This seemed to indicate that, by prolonging that curve, one would obtain the most favourable dimensions for those pipes of the first octave which M. Grenié had at first made of equal lengths. But, to his great surprise, he found that there

Organ. was no advantage whatever in doing so; but that, on the contrary, the sounds became very dull and irregular. He therefore reasonably adhered to his first construction, which, nevertheless, he still purposed to improve, by afterwards making all his porte-vents sliding tubes, so that each of them might have the most favourable length given to it. He has since constructed, on this same model, open reed-pipes of sixteen feet, which sound with very remarkable distinctness, strength, and regularity. In this case the tongue is a flat slip of copper, in length 0·240 of a metre, in breadth 0·035 of a metre, in thickness 0·003 of a metre; equal respectively to 9·449040, and 1·377985, and 0·118113 English inches and decimal parts. Its vibrations are so powerful, that they cause the pipe in which it is placed, the porte-vent over which it is mounted, and all neighbouring elastic bodies, to tremble. Of course, in order to make it sound, a powerful and well-managed bellows-force is necessary. That which M. Grenié employed was perfect in regularity and power. It had a double current of air, and was worked by one handle. M. Grenié obtained a patent for his improvements. He considered the mixture-stops in common organs as productive of nothing but bad effects, and therefore excluded them from his organ. (See report by Cherubini, Catel, Baillot, &c. in 1811.) We have given so full an account of Grenié's improvements, in order to excite the attention of British organ-builders to this subject, and induce them to discover many more improvements of which our organs are unquestionably susceptible.

One of the greatest steps to improvement in English organ-building was made upwards of twenty years ago, by Messrs Flight and Robson of London, in the construction of their magnificent organ, called the Apollonicon. It was exhibited to the public, and attracted vast numbers of visitors. The ingenuity of its mechanism, the excellence of its workmanship, the fineness of its tone, and the novelty and grandeur of its effects, were universally acknowledged. This fine instrument was played either by means of the revolutions of three large cylinders, or else by means of six different sets of finger-keys acted upon simultaneously by six different performers. The Apollonicon was about twenty-four feet high and twenty broad. We heard it in 1817, and were much struck by its varied and powerful effects. However, the room in which it was placed was neither sufficiently large, nor so proportioned in form, as to display the powers of this organ to the best advantage. This fine instrument alone is sufficient to bear us out in what we have said at the beginning of this article, as to the certainty of English organ-builders being able to rival, or to excel, the foreign ones, if they choose to exert themselves.

Several methods have been proposed in England to render the intonation of the organ less imperfect, by dividing the octave into a greater number of intervals than the usual twelve: amongst others, that employed in Hawke's patent organ, described in the thirty-sixth and thirty-ninth volumes of the Philosophical Magazine. Hawke divided the octave into seventeen intervals. Loeschman's patent organ was another of this kind. He divided the octave into twenty-four intervals, which were produced by six pedals and twelve finger-keys. (See description in vols. xxxvii. xxxviii. of Philosophical Magazine.) In 1810, the Rev. Henry Liston, a clever and ingenious Scottish clergyman, obtained a patent for an instrument, constructed by Messrs Flight and Robson, which he named the *Euharmonic Organ*. (See vol. xxxvii. of Philosophical Magazine.) Another organ, similar to the one last mentioned, was made for Mr Liston by the same builders. (See Philosophical Magazine, vol. xxxix.) It had eleven pedals, six of which were the same as those in Loeschman's organ. In the second organ built for Mr Liston, there was a contrivance for an occasional alteration of the pitch of the pipes, in the requisite degree, by means of flat metallic plates, which, when acted upon by the pedals, were brought, at due distances, over the tops of the open pipes, or opposite to the mouths of the stopped pipes, so as to flatten the pitch when this change was required. Organo-Lyricon.

The object of Mr Liston's organ was to supersede temperament; but although its ingenuity and its effects were admired by many of the best musicians in London, the complexity of its manuals and pedals prevented it from ever being generally adopted. And this has been the fate of all such instruments, in modern as well as in ancient times; for attempts of a similar kind were made, centuries ago, to introduce such minute subdivisions of the octave into keyed instruments. The Spanish writer Salinas, in his work *De Musica* (lib. iii. c. 27), speaks disparagingly of an instrument called an Archicymbalum, which had been constructed in Italy above forty years before the publication of his work in 1577, and in which every tone was divided into five parts. "Non silentio prætermittendum arbitror instrumentum quoddam, quod in Italia, citra quadraginta annos fabricari cœptum est, ab ejus autore, quisquis ille fuit, Archicymbalum appellatum. In quo reperiuntur omnes toni in quinque partes divisi: ex quibus tres vindicat sibi semitonium majus, et duas semitonium minus, a quibusdam magni nominis musicis in pretio habitum, et usu receptum: eo quod omnis in eo sonus habet omnia intervalla, atque omnes consonantias (ut sibi videntur) inferne, et superne, et post certam periodum ad eundem, aut equivalentem sibi sonum post 31 intervalla reditur," &c. In the latter part of the last century, F. X. Richter, chapel-master in the cathedral of Strasburg, usually composed upon a clavichord, which had twenty-one sounds to the octave, and which then seemed to be upwards of two hundred years old. Richter died in 1789, aged eighty.

An *Euharmonic Organ* was built by Messrs Robson, London, in 1856. It is, according to its inventor, an attempt to determine the just division of the canon or musical string in one key, and then apply the same proportions over again, beginning from some of the previously determined divisions. The result is the production of 38 manuals in the octave, divided among three finger-boards, and extending to 20 keys. The inventor has published an account of it (Wilson, Royal Exchange, London), with an appendix, tracing the identity of design with the enharmonic of the ancients.

(For some hints regarding the proper use of the organ, see the article Music. Those who wish to extend their knowledge of this subject will find abundance of information upon the history and the construction of the organ, and the art of playing it, in works published in Germany, France, and Italy. The German works are the most numerous. See in particular:—G. C. F. Schlimbach, *Ueber die Struktur, Erhaltung, Stimmung und Prüfung der Orgel*, Durchgesehen und Vermehrt von C. F. Becker, mit 5 kpfrt., gr. 8, Leipsic, 1843; *The Organ, its History and Construction*, by Dr Rimbault and E. J. Hopkins, Esq., London, 1856; C. H. Rink, *Practische Orgelschule*, in 6 parts, Leipsic, v. y., one of the best practical works on organ-playing.) (G. F. G.)

ORGANO-LYRICON, a musical instrument invented at Paris in 1810, by M. de Saint Pern. Its height is about eight feet two inches English, its breadth six feet six and a half inches, its depth about four feet four inches. It consists of a piano-forte, coupled with twelve different wind-instruments, viz., three kinds of flutes, an oboe, a clarinet, a bassoon, horns, trumpet, and fife. It has two rows of finger-keys. The lower row belongs to the piano-forte; but, by an ingenious mechanism, and according to the depression of the keys by the performer, it may be made to sound either the piano-forte alone, or a flute, or an oboe, or to unite them all. The upper row of finger-keys has

Orgia ‖ Oribasius.

no action on the piano-forte; but, by management of the pressure, it causes the German flute or the oboe to sound, and produces *rinforzi* by the gradual re-union of several wind-instruments. Independently of these functions, this row of finger-keys is destined for a great church-organ placed above it. The correspondence between the two rows of finger-keys is such that they may, at the will of the performer, act together or separately, or even partially. The finger-keys are singularly light in their touch, even at their maximum of depression. At the bottom of the instrument there are pedals for the double bass, and for other combinations. The wind-chests are numerous, and of such capacity that the wind of the large bellows which fill them cannot produce in them any augmentation injurious to the purity of the *timbre* and the trueness of the intonation. In this instrument, by means of ingenious contrivances, the inconveniences of an irregular supply of wind have been carefully avoided. A double pedal for the right foot enables the performer to work the bellows himself when he is alone. An adjacent pedal, turned the opposite way, enables an assistant to do this. But to avoid the trouble of these pedals, M. de Saint Pern placed in an adjoining room a large piece of clock-work, moved by a weight of fifty pounds, which served instead of a bellows-blower. The performer has beside him a mechanism that communicates with the clock-work, and, by means of a click and spring, leaves the weight going, or stops it at pleasure. (See report read to the French Institute on the 10th of September 1810; also report of the French Conservatory of Music, 12th August 1810, where it is said that "M. de Saint Pern's organo-lyricon might, in a large room or a chapel, hold the place of an orchestra, and imitate nearly all the effects of one." (G. F. G.)

ORGIA. See BACCHUS.

ORIA, a town of Spain, in Andalusia, province of Almeria, 32 miles N. of that town. It is ill and irregularly built; and contains a church, several hermitages, and a school. The inhabitants are engaged in agriculture, and linen manufactures. Pop. 5600.

ORIA, or *Uritania*, a town of Naples, province of Brindisi, and 22 miles W.S.W. of that town, has a picturesque site on a steep hill, surmounted by an ancient castle. It contains a cathedral, and is the see of a bishop. In the vicinity are extensive olive plantations, gardens, orchards, and vineyards. Trade is carried on in honey and wax. Pop. 4820.

ORIBASIUS, a celebrated Greek physician, was born in the former half of the fourth century at Pergamum, in Mysia, the birthplace of Galen. He studied medicine with success under Zeno of Cyprus, and soon acquired a great professional reputation. The chief cause, however, of the good fortune of his life was the steady friendship of Julian. On being elevated to the rank of Cæsar, that prince took the young physician along with him into Gaul, made him his confidant as well as his medical adviser, and employed him to write an epitome of Galen. After he had been proclaimed emperor in 361, he appointed him quæstor of Constantinople, and entrusted him with the vain enterprise of restoring the Delphic oracle. The death of Julian, in 363, left Oribasius exposed to the malice of his enemies. His goods were confiscated, and he was exiled to some barbarous country. Yet the imperturbable fortitude which he then began to manifest soon led to his triumphant recall. He set himself actively to practise his profession; the barbarians, astonished at his skill, scarcely refrained from paying him divine honours; his countrymen soon repented of having banished such an able physician, and so magnanimous a man; and in the course of a few years he was recalled and restored to his former position of wealth and esteem. The rest of his life was employed in writing, amid other engagements, a synopsis of his epitome of Galen, for the use of his son Eustathius. The date of his death is unknown. He was still living when Eunapius, the chief authority for his biography, about 395, inserted his Life in the *Vitæ Philosophorum et Sophistarum*.

Origen.

Of the several works which Oribasius is said to have written, three alone remain, either entire or fragmentary. His Συναγωγαι Ἰατρικαί, *Collecta Medicinalia*, originally in seventy books, now exists in the shape of twenty-five whole, and two fragmentary books. Although professedly an epitome of Galen, it contains many valuable extracts from other writers whose works are now lost. His Σύνοψις, consisting of nine books, and his Εὐπόριστα, consisting of four books, were published at Venice in Latin, by J. Bapt. Rasarius, the former in 1554, and the latter in 1558. The same editor also translated nineteen books of the other work of Oribasius, and published all these translations together in three volumes, 8vo, Basle, 1557.

ORIGEN (Ὠριγένης) was the son of an excellent Christian named Leonides, and was born in Alexandria about A.D. 186. His boyhood gave full promise of saint-like piety and great intellectual attainments. He loved to read the Scriptures, to commit large portions of them daily to memory, and to ask his father to explain the difficult passages. The good Leonides was wont of an evening to visit the couch of his sleeping child, and, uncovering the little bosom, to kiss it with the reverential thought that the Holy Spirit might dwell there. Although a pupil for some time of Clement of Alexandria, the boy did not permit the rationalistic teachings of his master to cloud the simple piety of his heart. When he heard in his sixteenth year that his father was apprehended for the truth, all the devotion of a martyr was stirred within him: he wrote to Leonides,—"See that you do not change your mind on our account;" and had not force been employed to detain him at home, he would have gone to meet death along with his parent.

All this promise began to be fulfilled in Origen when the martyrdom of his father had cast him destitute upon the world. At first he earned a livelihood by giving lessons in the Greek language and literature. Then, in course of time, being appointed to the gratuitous office of catechist by Demetrius, Bishop of Alexandria, he devoted himself with self-sacrificing ardour to the duties of a Christian teacher. All other employments were set aside: a choice collection of ancient authors was sold to supply the bare necessaries of life: the most pinching asceticism was practised: the moral precepts of the Bible were obeyed to the very letter; and in the height of his reckless fanaticism, he even "made himself an eunuch for the kingdom of heaven's sake." With the same devotedness did the youthful missionary discharge his public duties. In controversy, his fervid and affectionate address melted the stubborn prejudices of many a philosophic heathen: in the persecution under the government of Aquila, he communicated his pious heroism to his young converts; and when any of these were summoned to martyrdom, he appeared on the scaffold to cheer their departing spirits.

It was this same proselytizing ardour that now began to change the direction of Origen's theological studies and opinions. He saw that it was necessary to understand fully the tenets of the pagan philosophy before he could fully refute them. To learn these tenets, therefore, he set himself with all his one-sided intensity, and with a fixed determination to sympathize with whatever he might find beautiful and true. In Arabia, whither he was invited by the governor of that province; in Palestine, whither he fled to escape the massacre of Caracalla; at Antioch, where he had an interview with Mammæa, the mother of the Emperor Alexander Severus; at Cæsarea, where he was ordained a priest by the bishops of Palestine; and in Greece, whither he was sent, about 229, to refute heretics, every opportunity was taken to converse with learned heathens. At home the

Origen. tuition of the younger catechumens was given over to his friend Heraclas; his own attention was directed to delivering a course of lectures on the points of congruity between philosophy and Christianity; and from the distinguished heretics who did not disdain to sit at his feet he was ever ready to receive as well as to communicate instruction. In this manner was he gradually led to appropriate many of the dogmas of the old heathen philosophers. At the same time, it was necessary to show how these dogmas could be reconciled with the doctrines of the true religion. To this task, therefore, in the midst of his multifarious duties, he had applied himself, furnished with all external facilities of study by his friend and convert, the wealthy Ambrose, and carried forward by that force of unyielding application which gained for him the epithets of the "adamantine," the "brazen-bowelled" Origen. By the year 229 several of his commentaries, his *Treatise on the Resurrection*, his *Stromata*, and his work *On Principles*, had been completed. In all these, but especially in the last, he made the daring attempt to harmonize Platonism and Christianity, and to build up by means of the two a system of religious doctrine. There existed from all eternity, he held, one original essence and source of existence called the Father; co-eternal and co-equal with Him was the Son, the Logos ceaselessly proceeding from the everlasting mind, the ineffable brightness ever emanating from the Divine glory; and joined with these two persons in trinal unity, although created like all other spirits by the Son, was the Holy Ghost. Since the exercise of creative power is essential to the being of the Godhead, there also existed from all eternity a succession of worlds. To fill these worlds, a number of *intelligences* were created. These were clothed with bodies of an ethereal rarity, for God alone is incorporeal; and they were all created alike, for God cannot be the author of inequality. Free-will was bestowed upon them, and the exercise of this soon began to lead them into depravity, and to alter in various degrees their original conditions. They were degraded into *souls*, were imprisoned in gross material bodies, and, according to their different degrees of degeneracy, became angels, men, or demons. The Logos then undertook to restore them by revealing himself. To men he made this revelation by uniting himself with the most perfect *intelligence*, and by connecting himself through that medium with a body of flesh; and to angels and demons he employed in a similar manner modes suited to their different states and capacities. Thus, all created spirits, including Satan himself, will eventually be restored; a new state of probation will then commence; they will fall again through the exercise of free-will; and the succession of worlds as places of reformatory punishment will require to be continued.

The adoption of a doctrinal system so seemingly contradictory to Scripture as this forced Origen to assume a new style of biblical interpretation. It was impossible, he held, that such sublime spiritual truths, when stated abstractly, could be understood by the generality of men; they must therefore from necessity have been clothed by the sacred writers in palpable figures and allegories; and, accordingly, there is often a mystical meaning lying concealed behind the letter of holy writ. The very attention which Origen bestowed upon the construction of this erroneous allegorizing method led him at the same time to render a great service to the cause of hermeneutics. He found it necessary in many cases to adopt the bare letter of the word: this induced him to lay down an accurate distinction between the verbal and spiritual sense; and he thus had the merit of establishing a new and improved school of grammatical interpretation.

It is likely that these opinions contributed in some degree to exasperate the series of troubles that began to harass him about 229. After this date his life is the picture of a great Christian teacher labouring patiently for the reward of a good conscience amid the persecuting malice of an ungrateful world. Demetrius, Bishop of Alexandria, offended at the ordination of Origen by the bishops of Palestine, raked up every private scandal that might be thrown against his reputation, and procured his banishment from Egypt. Yet the uncomplaining exile, setting up his humble household among his friends in Cæsarea, continued his biblical labours without remission. The thunders of excommunication soon followed him thither, and awoke a stormy controversy on his account between the churches of Rome and Alexandria, on the one hand, and the churches of Palestine, Phœnicia, Achaia, and Arabia, on the other. Yet the enthusiastic teacher was meanwhile lecturing on theology, philosophy, logic, natural science, geometry, astronomy, and ethics, with an eloquence "unspeakably winning, hallowed, and passing lovely." The persecution of the Emperor Maximinus in 235 drove him to seek refuge in Cappadocia, in the house of a wealthy lady named Juliana. Yet the two years of his concealment were employed in the compilation of his *Hexapla*, a work which exhibited in six, eight, or nine parallel columns, according as the case required, the various copies of the Old Testament. In the Decian persecution, which began in 249, he was cast into a dungeon in Tyre, and subjected to the most exquisite and protracted inquisitorial tortures. Yet not only did the old man vindicate the sufficiency of his Christian faith by his pious endurance, but he also wrote letters to console and confirm his fellow-sufferers. These accumulated toils and hardships at length undermined the health of Origen; and in the course of two or three years after his liberation from prison, he died about 254, and was buried at Tyre. Origen.

The works which Origen left behind him were so numerous that they were estimated by Epiphanius to amount to six thousand. By far the greater part is lost. Some of them, such as the treatise *On Prayer*, the *Exhortation to Martyrdom*, and the apologetic pamphlet *Against Celsus*, are extant; others, such as the *Hexapla*, and the *Commentaries* on the books of the Old and New Testament, exist in fragments; and others, such as his work *On Principles*, are preserved by Rufinus in Latin translations, which professedly attempt to improve the originals, both by omissions and interpolations. The best edition of the fragments of the *Hexapla* is that of Montfaucon, in 2 vols. fol., Paris, 1713. The collected works of Origen were published in Latin at different times during the sixteenth century, by Merlin, Erasmus, Panzer, and Genebrard. The standard edition is that of Charles and Vincent Delarue, in 4 vols. fol., Paris, 1733-59. Several fragments of Origen appeared for the first time in the 14th volume of Gallard's *Bibliotheca Patrum*, published in 1781. A list of his works is given in the *Bibliotheca Græca* of Fabricius. (For the biography of Origen, the standard authority is the *Historia Ecclesiastica* of Eusebius. See also, among many other works, Huet's *Origeniana;* Neander's *Church History;* and *Origenes, Darstellung Seines Lebens und Seiner Lehre* von Ernst Rudolph Redepenning, in 2 vols. 8vo., Bonn, 1841-46.)

The opinions of Origen gave rise many years after his death to a great controversy in the church. It was begun in the fourth century by a party accusing him of being the founder of Arianism; then a faction of the Egyptian monks came forward in his defence; and the dispute was brought to a head by Rufinus adopting the latter side, and Jerome adopting the former. From this time, the *Origenists*, though soon suppressed in the Western Church, began to rise into importance in the East. In the fifth century they had secured a firm footing in Egypt, Syria, and the adjacent countries; and in the sixth century they had acquired great influence in the palace of the Emperor Justinian. Their

Orihuela. Orinoco.

doctrines, however, were finally condemned; and their sect was broken up by a general council, held at Constantinople in 553.

ORIHUELA, a town and episcopal see of Spain, situated in the kingdom and province of Valencia, on its S. boundary, at the foot of a limestone ridge of moderate height, and on both sides of the Segura, which crosses it from W. to E., the communication being maintained by two bridges. The town is not fortified, but there are extensive ruins of a fort on the hill commanding it; and the entrance to the town, on the side of Valencia—the Puerto del Colegio, is a fine lofty arch, surmounted by a stone figure and the city arms. The episcopal palace, erected by Osorio, the bishop, in 1733, has a front of 600 feet in the Calle Mayor, and on the other side is washed by the Segura, by whose inundations it has been much damaged at various times, and is in a ruinous condition; it contains a public library. Among the other principal buildings are,—a large barracks at the Murcia gate, also partly ruined, and a new casa consistorial, in which the municipal archives, containing a great number of curious and important documents of national history are preserved. The cathedral is an ancient Gothic structure, erected on the site of a mosque; it was enlarged in 1829, and tastelessly decorated. There are three other parish churches. The most ancient of the convents is that of the friars of St Augustine. That of the Franciscans, on the Murcia Road, is a building of different epochs, with a fine large garden. There is a Carmelite convent in the centre of the town, and six other convents of less note, among which may be reckoned, as a kind of convent, the Colegia Patriarcal de Predicadores, at the E. entrance, with a fine church and library. There are three convents of nuns and three of ermitas within the town, the most remarkable being that of our Lady of Monserrat, whose image is carried in procession to the cathedral in times of public calamity. The university of Orihuela, founded in 1568 by Fernando de Loances, Archbishop of Valencia, was suppressed in 1835, and part of its revenue applied to the foundation of a college in the university of Valencia. Other educational establishments are,—the theological seminary of San Miguel, founded in 1733 by the bishop Gomez de Teran, containing a fine library and the archives of the diocese; the normal school of the province; and six public elementary schools, besides private institutions. There is an hospital; also a poor-house, founded in 1743 by the bishop just named, and enlarged in 1818; it is capacious and well endowed. Opposite to it stands the maternity hospital, founded in 1764. Agriculture is the principal occupation of the inhabitants, but there are manufactures of woollen and linen cloths, leather, sombreros, and saltpetre; also silk and cotton dye-works. There is a daily corn-market, and a weekly market for all goods on Tuesday, which is well attended. Orihuela is a Roman town, as is testified by ruins and by coins discovered; but unless it be the Orcelis of Pliny there is no mention of it in ancient geography. It was a place of some importance in the Moorish invasion, and was held in 713 successfully by Theodoric against Abd-el-Aziz after the battle of the Guadalete. It was conquered in 1265 by Don Jaime of Aragon for his father-in-law, Don Alonso, King of Castile. The city was sacked in 1520 in the civil war at that time raging, and again in the war of the succession, 1706. In 1648 it was devastated by the plague; in 1651 by an inundation of the river; in the earthquake of 21st March 1829 many houses were destroyed and churches damaged. In the last civil war the city was distinguished by its Carlist tendencies, and was held for some time in 1837 by the Carlist general Forcadell. Pop. in 1849, 17,452.

ORINOCO, a large river of Venezuela, South America. Its source has never yet been visited by European travellers; for although both Baron Humboldt in 1800, and Schomburgk in 1838, penetrated very near the place where it takes its rise, yet both these travellers were prevented from reaching it by the treacherous outrages of the Kirishana savages who inhabit the district adjacent to the source. The latter of these travellers, however, reduced the limits within which the actual head is to be found to a space of 30 miles. The reports of the Indian tribes on the banks of the river agree in placing the source of the Orinoco in the Parima Mountains, on the borders of Brazil and Venezuela, not far from that of the Parima, which flows in an opposite direction, between 3° and 4° N. Lat., and about 64° W. Long. It flows at first W.N.W., and receives from the N. the Paramu, a river remarkable for the number and height of its falls. Below its confluence with this river the Orinoco is broad, but shallow, and much interrupted by sand-banks. It flows sluggishly through a low, flat region, broken only by a few scattered hills densely wooded. About 13 miles below the village of Esmeralda, the most remote Christian settlement on the river, the Orinoco divides itself into two branches; one of which, taking the name of the Cassiquiare, or Cassisiare, flows S.W., and, after a course of 120 miles, joins the Rio Negro near San Carlos; while the other branch, retaining the name of Orinoco, continues to pursue a N.W. direction. The former of these thus forms a sort of natural canal, joining the waters of the Orinoco with those of the Amazon, of which river the Rio Negro is an affluent; and, as the waters of the Amazon are only separated from those of the Paraguay in the south by a portage of three miles, there is, with this exception, a continuous communication by navigable rivers from Buenos Ayres in S. Lat. 35. to the mouths of the Orinoco in N. Lat. 9. Below its bifurcation the Orinoco skirts the base of the Parima Mountains, and receives the Ventuari from the right, and still further down the Guaviare from the left. After its confluence with these rivers, in W. Long. 68., it changes its direction, and flows for some distance due north, skirting the western foot of the Parima Mountains. In this part of its course the navigation is interrupted by the rapids, or *Raudales*, as they are called, of Maypures and Atures, the former 80, and the latter 116 miles below the confluence of the Guaviare with the Orinoco. The river is here more than 8000 feet broad, but is so broken up by an immense number of small islands and rocks, as to leave, in many places, a channel no broader than 20 feet. Between these islands there are numerous cascades, not exceeding 9 feet in height; but, as the great body of water flows through these narrow openings with great force and rapidity, any attempt to ascend the rapids in boats must inevitably be followed by the destruction of the boat and great danger to the lives of the daring navigators. Below this point the navigation is not again interrupted; but at the confluence of the Meta, a tributary which joins the Orinoco from the W., there is a whirlpool which occasions considerable delay to the voyager. From its bifurcation to the confluence of the Meta, the Orinoco forms the boundary between Venezuela on the E., and New Granada on the W. To the north of this point the river takes a curve towards the N.E., and, after receiving the Apure from the left, it flows nearly due E. to the Atlantic. About 130 miles from the sea it forms a delta, by sending to the N. a branch which divides itself into several streams, called the *Bocas Chicas*, or small mouths, and falling partly into the Gulf of Paria and partly into the Atlantic. These, though many of them are navigable and of considerable size, are much less than the main stream, which is called the *Boca de Navios*, and is divided, for the distance of about 40 miles, by a line of islands in the middle, into two channels, each about two miles wide. At the great mouth of the river the breadth is upwards of 60 miles, and there extends across the navigable channel in the centre a sand-bar with 17 feet of water. The length of the Orinoco is estimated at 1600 miles, for about half of which distance it is navigable. It receives more than 400

Orinoco.

Orion ‖ Orissa.

navigable tributaries, the largest of which have been already noticed. At a distance of 560 miles from the sea this great river exceeds 3 miles in breadth. The tide reaches as far as Bolivar, more than 250 miles from its mouth; and at this place the breadth is 4 miles, and the depth 65 fathoms.

The area of the country watered by the Orinoco and its tributaries is estimated at 200,000 square miles. This region is entirely occupied by the *llanos*, or levels of Venezuela—immense flat plains, stretching from the coast chain to the Parima Mountains, and from the Atlantic to the Andes, rising in some parts of the coast to the height of 1300 feet; but in many places hardly at all above the level of the sea. The greater part of these plains is entirely destitute of trees; but the region on both sides of the Guaviare, and thence northwards along the left bank of the Orinoco to the Meta, is covered with dense forests. In the dry season the open plains present an arid and barren appearance, but when the rain falls they are suddenly covered with luxuriant vegetation; the rivers overflow, cover the plains with vast sheets of water, and sometimes extend even into the forests. The rising of the Orinoco begins in the end of March, proceeds slowly at first till it attains its greatest height in July and August, and then, more slowly than it rose, decreases. Its greatest height on an average at Bolivar is 24 or 25 feet, but in the upper part of its course it attains a height of about 30 feet, and in one contracted channel it is said to rise 120 feet above its ordinary level.

ORION, a hero of ancient classical mythology, was, according to the ordinary account, a son of Hyricus and a native of Hyria in Bœotia. His gigantic height and his prowess as a hunter soon led him into a series of adventures. Arriving in the course of his travels at Ophiusa, he fell in love with Merope, the beautiful daughter of Œnopion, and agreed as a price for her hand to exterminate all the wild beasts in the island. The rugged hunter, however, when he had performed his task, was too precipitate in exacting the reward. The offended father, in revenge, put out his eyes as he lay in a drunken sleep. The blinded giant, on returning to consciousness, was informed by an oracle that he might recover his sight by exposing his empty sockets to the rays of the rising sun. Wandering eastward through the sea, and directing his course towards a far-ringing anvil, he soon found himself in the forge of Vulcan, in the island of Lemnos. One of the workmen undertook to be his guide; and, sitting upon his shoulders, directed his footsteps to a place where his eyes were suddenly cured. Orion now hastened back to Ophiusa to take vengeance upon Œnopion. Not finding him, however, he repaired to Crete, and entering the hunting train of Diana, he continued in that position till his death. How that event happened it is not agreed among authors. The ordinary legend is that he was shot by one of his mistress's arrows for an offence which is differently represented by different writers. Another opinion reports him to have been killed by a scorpion. At any rate, it is the common belief that he was changed on his demise into a constellation. As his rising was generally supposed to bring storms, he came to be called the "shower-bringing," "cloudy," or "rainy" Orion.

ORISSA, an extensive province of Hindustan, in the Deccan, between N. Lat. 17. 16. and 22. 23. E. Long. 81. 35. and 87. 20. It has Bengal for its boundary to the N., to the S. the River Godavery, to the E. the Bay of Bengal, and to the W. the province of Gundwana. It may be estimated from N.E. to S.W. at 400 miles in length by 70 in average breadth. This province, in the interior, is of a rude and barbarous aspect, consisting for the most part of rugged hills, uninhabited jungles, and deep water-courses. It is surrounded by pathless deserts, forests, or valleys; and the atmosphere is pestilential. At present the British rule over nearly one half of this extensive region and the remaining part, is possessed by tributary zemindars, who pay a fixed rent to the British, under whose jurisdiction they live. The woody and interior division of the country belongs to them; whilst the other division, belonging to the British, comprehends all the low lands extending along the coast, a tract generally plain and fertile, but not well cultivated or peopled. The low lands along the Bay of Bengal abound with wild animals, such as hogs, deer, tigers, and jackals; and the high lands are infested by such numbers of wild animals, that in many places they are regaining possession of the country from which they were driven by the progress of cultivation. Fish swarm in the rivers, which are also infested with reptiles and alligators; and in the plains and jungles are innumerable noxious insects. The chief rivers are the Godavery and Mahanuddy, besides innumerable mountain streams of a short course. The inhabitants of Orissa belong to four principal tribes:—1. The Urias, Orias, or Odras, who occupy the plains and valleys, especially towards the W. 2. The Coles, also called Hos, in the N., a tribe in a half savage condition, remarkable for honesty, truthfulness, and good nature. 3. The Khonds, in the centre of the country, who have made some progress in civilization; but practise abominable superstitious rites, with human sacrifices, which have been attempted, but hitherto in vain, to be suppressed by the British government. 4. The Saurias, or Sauras, in the S., who, though in general peaceable and harmless, are addicted to the same superstitions as the Khonds, and are even more wild and savage than they. A race of Hindu princes governed the country till 1592, when they were conquered by the viceroy of Akbar, to whose dominion the country was annexed as a dependent government. From disjointed fragments of its history, and from existing relics, it appears to have been a flourishing empire, even before the Mohammedan invasion; but it soon afterwards fell into decay. Pop. about 4,534,813.

Oristano ‖ Orkney Islands.

ORISTANO, a town of the island of Sardinia, capital of a province of the same name, in the division of Cagliari, stands in the midst of salt marshes, about a mile from the left bank of the Tirsi, about 3 miles from the W. coast of the island, and 30 N.N.W. of Cagliari. It has a low and unhealthy situation, and a very desolate appearance, which is not at all in keeping with the turreted wall which surrounds the town, or the handsome houses which still bear the arms of the Spanish nobles who lived here when Sardinia was a dependency of Spain. It seems probable that in former times the salt marshes here were not so extensive as they now are; so that the site of the town would not have been originally an unfavourable one. Out of several churches, the only noteworthy one is the cathedral, a modern building, which contains several good paintings. There is an old palace, once the residence of the judges of Arborea, a convent, several schools, and an hospital. Manufactures of ironware, cutlery, arms, and other implements, are carried on. Pop. 6000.

ORIZABA, a town of Mexico, department of Vera Cruz, 65 miles S.W. of the town of Vera Cruz. It stands in a valley overgrown with forests, and has broad and well paved streets. Manufactures of leather and coarse cloth are carried on here. Pop. 15,500.

About 5 miles N. of the town stands the Peak of Orizaba, an extinct volcano, which has a height of 17,388 feet above the sea. It was first ascended in 1848 by Lieutenant Reynolds, and other American officers, having before been supposed inaccessible; and since that time the summit has been repeatedly reached.

ORKNEY ISLANDS, or ORCADES, a group of islands in the North Sea, which, with the sister group of the Zetlands, form one of the counties of Scotland. They are separated from Caithness by the Pentland Firth, a strait of about 8 miles in breadth, and are situated between the parallels

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58. 44. and 59. 24. N. Lat., and between 2. 24. and 3. 20. W. Long. In number they amount to sixty-seven, of which twenty-seven are inhabited, and the others, known by the name of *holms*, are employed principally as grazing grounds for sheep and black cattle. The islands are divided into two groups, called—in reference to Pomona,[1] the principal island—the North and South Isles. The following are the names of the inhabited islands, with their population, according to the census taken in 1851 :—

SOUTH ISLES.	Pop.	NORTH ISLES.	Pop.
South Ronaldshey	2438	Sandey	2004
Walls and Hoy	1555	Westrey and Papa Westrey	2459
Flotey and Farey	441	Stronsey and Papa Stronsey	1211
Burrey	559	Rousey and Enhallow	961
Græmsey	286	Shapinshey	899
Swaney and the Skerries	57	Edey and Pharey	1016
Copenshey	11	North Ronaldshey	526
Hundey	5	Eagleshey	192
Cavey	24	Weir	62
Lambholm	13	Gairsey	41
	5389		9371

Pomona, or the Mainland, has a population of 16,695; and thus the whole number of inhabitants amounts to 31,455. The number in 1831 was 28,847.

In the absence of an accurate survey it is impossible to give anything like a correct estimate of the extent of the country. We have heard the number of square acres fixed at 150,000, and we have heard that number doubled. The very irregular form of the islands, penetrated by arms of the sea in all directions, easily accounts for this diversity of opinion.

The general appearance of the islands is bleak, and upon the whole uninteresting. The want of wood, and the tracts of waste uncultivated land, though these are diminishing in number and extent, present a somewhat forbidding aspect.

Orkney is divided into twenty-two parishes, forming three presbyteries and one synod. There are also fourteen Free Church congregations, thirteen congregations in connection with the United Presbyterian Church, and three Independent congregations, in Orkney. Together with Zetland, these islands constitute one sheriffdom, or stewartry, under the jurisdiction of a sheriff-depute and two substitutes, whose courts are held at Kirkwall and Lerwick. Till the passing of the Reform Bill, Orkney alone had the privilege of returning a member to Parliament—the landholders of Zetland, owing to the want of a separate valuation of their estates, having no vote in the election. In 1857 the parliamentary constituency amounted to 617; and of these there were 422 voters belonging to Orkney, and 195 to Zetland. Of the land-tax payable for the county, two-thirds are levied from Orkney, and one-third from the northern division of the stewartry.

We shall now proceed to notice the principal islands, and to point out the most remarkable objects in them.

The most southerly is South Ronaldshey, containing 24 square miles, and a population that has increased during the last twenty years by 200, chiefly employed in agriculture, and the cod, herring, and lobster fisheries. There are two excellent harbours in this island—Widewall Bay on the west, and St Margaret's Hope on the north. The antiquities of the island are,—several Picts' houses, three or four monumental stones of large size, and the Howe of Hoxa, an ancient stronghold.

To the north-west of South Ronaldshey lies Hoy, in many respects the most interesting of all the smaller islands. It contains the Ward or Wart Hill, rising to the height of almost 1600 feet, the loftiest mountain in Orkney; the towering precipices of Rorey and Rackwick, washed by the fury of the Western Ocean; the huge isolated rock called the Old Man of Hoy; the Meadow of the Kaim; the beautiful vale of Berrydale, through which flows a stream whose banks are fringed with birches, creeping juniper, and willows; and the "Dwarfie Stone,"—objects which will repay a lengthened visit. Forming part of the island of Hoy, but constituting a different parish, is Walls, or Waas, distinguished chiefly for its excellent harbour, Long Hope, which is partially defended by a small battery and a couple of martello towers. Burrey, situated to the north of South Ronaldshey, and separated from it by a channel of a mile in breadth, has an area of only 3 square miles, but produces grain, green crops, and good pasture, and has moreover a valuable rabbit-warren. Farther north is the largest island of the group, Pomona, or Mainland, extending to 30 miles in length, and containing upwards of 200 square miles. The towns of Kirkwall and Stromness are in this island. (See articles KIRKWALL and STROMNESS.) Excepting Kirkwall, Stennis on the Mainland has the greatest claims on the attention of the traveller and the antiquary. Here are the "Stones of Stennis," two collections of what at one time must have been upright pillars, forming a circle and a semicircle. Many of these stones are now overthrown; but the circle, when complete, seems to have been formed of sixty pillars, of which thirteen still remain erect and perfect; ten more are prostrate, though unbroken, and the fragments of thirty others are still visible. The stones vary from 10 to 16 feet in height, and from 2½ to 5 feet in breadth. The entire circle is surrounded by a trench about 20 feet in width, and the diameter of the included space cannot be less than 300 feet. There have been many conjectures as to the purpose of these erections; and it is by no means certain by whom they were raised. One opinion is that they are of Druidical, and another that they are of Scandinavian origin. A not improbable conjecture is, that the circle was dedicated to the sun, and the semicircle to the moon, the frequent objects of Scandinavian worship. Of these stones the most interesting was one which stood near to, but did not form part of the circle. It was perforated by a small hole, through which the heads of children were passed in order to secure them against palsy in after-life; and through that hole also lovers' hands were joined in token that the vows there made should be faithfully kept. These contracts were deemed peculiarly binding, and the promise of Odin was regarded by an Orkney man as of too solemn a nature to be trifled with. The malice or stupidity of a stranger, who rented a neighbouring farm, induced him in 1814 to overthrow and break to pieces this curious relic of ancient times. In front of the circle lies a large horizontal stone, conjectured to have been used for sacrificial purposes; and it has been thought that it was on this altar that Einar, Jarl of Orkney, son of Ronald, about the year 893, or, according to other accounts, 930, stretched Halfdan, the son of Harold the Fair-haired, King of Norway, and tearing out his lungs, presented the reeking gift to his god.

In the adjoining parish of Sandwick, the grandeur of the rocks must attract the notice of the visitor; and one huge archway, formed by the restless fury of the waves, called the *Hollow Row*, or Hole of Row, is specially deserving of attention.

Robert Stewart, Earl of Orkney, had a palace in Birsey, the next parish on the N.W., the ruins of which still remain. Brand, who visited the country in 1700, says:—"The palace is two stories high; the upper hath been prettily decored, the ceiling being all painted, and that for the most part with schems, holding forth Scripture histories,—as Noah's flood, Christ's riding to Jerusalem,—and the Scripture is set down beside the figure. It was inhabited within these twenty years, but is now fast decaying."

[1] For some conjectures as to the origin of this name, see the *Proceedings of the Society of Antiquaries of Scotland*, vol. i., p. 16.

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About forty years ago, the writer of this article saw the palace. All the decorations, the roof, and a great part of the walls, were then gone; and the clergyman of the parish informed him that the ruins had long been regarded as a common quarry, whence any intending builder drew materials for the erection of his house. It was over the gateway of this building that the inscription was placed, which, owing to a grammatical error, was seized on as affording evidence of the treasonable designs of the family on the trial of Patrick, Earl Robert's son: "Dominus Robertus Stuartus, filius Jacobi quinti *rex* Scotorum, hoc opus instruxit." The two islands of Shapinshey and Rousey, each containing from 10 to 12 square miles, lie to the N. of the Mainland. The former is flat; in the latter the highest hills, save those of Hoy, are found. In Shapinshey, great improvements in various ways have lately been effected, and the resident proprietor has erected a stately mansion-house, the largest in the county. Rousey presents to the antiquary for his investigation, tumuli, Picts' houses, standing stones, and a number of ancient graves. Planting has recently and to some extent, and not without a very considerable measure of success, been attempted in the island. To the E. of Rousey is the beautiful islet of Eagleshey, the favourite summer residence of the ancient jarls, and at a later period, of the bishops of Orkney. It was here that St Magnus, the tutelar saint of the islands, was basely murdered by his cousin Hacon in 1110. On the highest part of the island stands the ancient chapel dedicated to St Magnus. Beyond these, to the N.E., lie Stronsey, where there is an extensive fishing station, and Edey, that can boast of a burgh of barony. Still farther N. lie Sandey on the E., and Westrey on the W. The former, because of its productiveness, has been called the granary of Orkney; it is a flat, low-lying island; and, till the erection of a lighthouse on the point of Start in 1806, proved fatal to many a vessel. Westrey is, with the exception of Sandey, the largest of the North Isles. In it are the remains of the strong castle of Noltland, begun by Thomas Tulloch, Bishop of Orkney, between 1422 and 1448, and whose initials, T. T., are to be seen on the pillar that supports the great staircase. The castle was never completed; and a traveller, who describes it under the date of 1529, says—"Est excellentissima arx, sive castellum, sed nondum tamen adhuc completa." In consequence of sand blowing, a number of graves, containing, among bones, the remains of various weapons, have been uncovered. These places of sepulture are generally formed of five stones, four standing on their edges and resting on the fifth. Separated from Westrey by a firth of a mile in breadth, is the small island of Papa Westrey, with its beautiful fresh-water loch, in the midst of which is a small island, on which a chapel dedicated to St Tredwall stood. The most northerly of the islands is North Ronaldshey, containing an area of from four to six square miles. It was on a reef near this island that the "Suetia" of Gottenburg, an Indiaman, valued at half a million sterling, was wrecked in 1740; and here too, four years afterwards, another Indiaman, "The Crown Prince of Denmark," with thirty chests of treasure, was cast away.

The geology of the islands, though not presenting much variety, is interesting, and worthy of attention from the vast numbers of ichthyolites to be found. There is a central nucleus or backbone of granite or gray gneiss, extending for about six miles, around which, or diverging from which, runs an immense development of the Devonian formation, or lower Old Red Sandstone. As is almost invariably the case, the sandstone is found disrupted and distorted by the upheaved trap, and the picturesque grandeur of the iron-bound coast is much owing to the washing away of the softer and interposed materials, leaving the more conservative whin dykes (greenstone, basalt, porphyry, &c.) pierced and perforated and hollowed out into a thousand fantastic, but not the less magnificent shapes. The Asterolepis, that gives the title to one of his best known works, was found by Mr Hugh Miller in the immediate neighbourhood of Stromness.

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The Orkney flora is known to consist of 545 species, and there can be little doubt that additions will be made to this number as more careful examinations are made. The only Orkney plant new to the British flora is the *Chara aspera*, first seen by the Rev. Charles Clouston, minister of Sandwick. Considerable attention, and not without results, has lately been paid to the algæ and fucoid plants.

The *Fauna Orcadensis* of Low enumerates—of quadrupeds, 11 genera; of birds, 34 genera; of reptiles, 2 genera; and of fishes, 33 genera.

The following remarks on the climate of Orkney, by the Rev. Charles Clouston, contain matter at once new and interesting, and we allow his observations to speak for themselves, merely adding, in a sentence, that an Orkney summer has many and peculiar charms,—the length of day, the duration of twilight, the rapid vegetation, and above all, the stillness of the sleeping ocean on a calm evening, compensate in no small degree for the absence of other beauties.

The following table gives the mean monthly and annual temperature of Orkney, deduced from observations made twice a-day for thirty-one years; the first six at the manse of Stromness, about half a mile from the sea, and not 100 feet above its level, and the remaining twenty-five at that of Sandwick, 2 miles from the sea, and 100 feet above its level; also the mean monthly and annual state of the barometer for nineteen years at the manse of Sandwick; and the mean monthly and annual quantity of rain that fell at the same place for the last seventeen years:—

Months.	Thermometer.	Barometer.	Hygrometer.
January	38·35	29·565	4·26
February	38·18	29·682	3·18
March	40·36	29·815	2·55
April	43·45	29·829	1·78
May	47·82	29·880	1·57
June	52·76	29·836	2·15
July	55·20	29·802	2·52
August	55·03	29·785	2·89
September	52·47	29·851	2·71
October	47·67	29·710	4·71
November	42·73	29·697	4·02
December	41·10	29·690	4·33
Annual	46·26	29·762	36·66

Strangers naturally form a very wrong and unfavourable opinion of the climate of Orkney, and its peculiarities are only beginning to be understood by even the best informed of its own inhabitants. From these observations it has been ascertained, that the mean annual temperature of Orkney is not only equal to that of the north and middle of Scotland, but even to that of the southern border; for, on comparing the Orkney table of temperature for the last thirty-one years, with one for twenty years kept by that accurate observer Dr Dunbar of Applegarth, Dumfriesshire, we find the mean temperature of Orkney to be 46°·26, and that of Applegarth 46°·24—the difference being in favour of Orkney, but so minute, that they may be considered equal. While, however, this station in Dumfries is between 4° and 5° colder than Orkney in December and January, its temperature gradually rises, till, in July, which is the warmest month in both places, it is above 3° warmer than Orkney. The mildness of the Orkney winter is indeed so great, that the mean temperature of December, January, and February there, is higher than that of several parts of England.

This arrangement may be pleasant or favourable to animal life; but it is far from being favourable to vegetation, as the luxuriance of the common crops depends on the temperature of three or four months in summer while they are in the ground, and not at all on that of the rest of the year. This equability of temperature injurious as it is to the growth of common annual crops, is doubly so to such perennials as trees, as there is neither such extreme

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heat in summer as to mature the wood of the young branches, which are therefore killed in winter; nor such extreme cold in winter as to lay vegetation completely asleep. Evergreens are particularly sickly in Orkney. The sea-spray in winter, which frequently loads the air, and falls and crystallizes on their leaves, renders them much more liable to be killed than other kinds of trees, some of which grow under shelter to the height of 20 or 30 feet.

The difference between the mean temperature of February, which is the coldest month (38°·18), and that of July, which is the warmest (55°·20), is only about 17°; and during all the period of observation, the mean temperature of any month never fell so low as the freezing point, except in February 1838 and February 1855, when it was respectively 31°·31 and 31°·64; and it never rose so high as 60°, except in 1852, when it was 61°·36.

In Britain generally, and particularly in the inland parts, the greatest heat occurs about the middle of July, and the greatest cold about the middle of January; and the months equidistant from these are most nearly of equal temperature, as February and December. In Orkney, however, February is the coldest month, though only 0°·17 colder than January; and August is just the same decimal of a degree colder than July. Indeed, in the course of these thirty-one years, January has been colder than February sixteen years, and August has been hotter than July twelve years; so that January and February may be considered equally cold, and July and August equally warm; and the months equidistant from them on each side will be found to correspond most nearly in temperature, as March and December, and again, June and September. These facts are undoubted; and meteorologists agree in ascribing this retardation of the period of extreme heat and cold to the influence of the surrounding ocean, which is neither so quickly heated in summer, nor cooled in winter, as the surface of the land.

During these thirty-one years the thermometer was once observed as low as 14½° on 16th March 1845, and once as high as 75° on 5th June 1846, but this was without the aid of registering thermometers, which have only been used for about two years.

The mean state of the barometer for the last nineteen years is 29·762 inches; or, when corrected to 32° and sea-level, to enable us to compare it with other places, 29·839 inches. This does not differ materially from its mean height in other parts of Scotland; the mean of about fifty places published by the Scottish Meteorological Society, being for 1856, 29·869 inches, and for 1857, 29·894 inches; the mean of both being 29·881 inches, while the mean of Orkney was, for 1856, 29·898 inches, and for 1857, 29·881 inches; the mean of both being 29·889 inches, or a minute decimal of ·008 above the other districts. So far as yet ascertained, therefore, they may be considered equal.

The barometer generally attains its greatest height in May, and gradually descends on each side, the only exception being September, when it takes a step upward, probably indicating the period of the Orkney "peerie summer." The gradual descent from the maximum height becomes prominent only in a long series of observations. The same tendency may be perceived in the tables published in the *New Statistical Account* of Sandwick and of St Andrews, though the descent is not so regular, and in the latter the greatest height is in June. On the 24th January 1840 the mercury was as low as 27·69 inches, and on 1st February 1841, as high as 31·76 inches; giving a range during these nineteen years of 4·07 inches.

The average annual quantity of rain that fell at Sandwick Manse, during the last seventeen years, is 36·66 inches. This is more than 10 inches above Dr Barry's estimate, which had been assumed as correct by others, without actual measurement. The paucity of observations in other places renders it impossible to say at present whether this is above or below the average for Scotland; and, indeed, much would depend on the situation of those places from which that average was struck. It will probably be found equal to the average fall in the interior of Scotland and England,—below what is stated to fall on the west coast, and above that on the east. If an extensive table now before us is to be relied on, it is about equal to the fall in Applegarth, Liverpool, and Swansea, which is 34 inches; Dumfries and Manchester, 36; Langholm, Dover, and Selborne, 37; Aberdeenshire, 38: while it is decidedly above Edinburgh, which is 26 inches; York, 22, and London, 20: and below Glasgow, which is 40 inches; Ayrshire, 42; Whitehaven, 48; Restwick, 67; and Easthwaite, 86. From the reports of the Meteorological Society, published for 1856 and 1857, it appears that the average of all their stations for these two years was 31·78 inches; while the average of Orkney for the same years was only 29·66 inches, which makes Orkney appear particularly dry; but it would be unfair to found such a conclusion on such a limited period of observation. They must rather be considered as exceptional years, being the driest in Orkney during the period of registration, so that the crops were injured by excessive drought, while there was excessive rain in more southerly districts, from which the crops there suffered severely. May has the least rain, as well as the highest barometer; and the preceding months, embracing the previous December, have more rain the more they precede it. Again, the quantity gradually increases in the succeeding months till October, which is decidedly the wettest, only indicating the "peerie summer" in September by a somewhat smaller fall than during the "Lammas speats" in August.

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The direction and force of the wind has also been noted every morning and evening for thirty-one years. The W. used to be considered the most prevalent wind in Orkney, but from this it appears not to have been so for the period noted. It blew from the W., S.W., S., and S.E., 6710 days; while, from the opposite four points, it blew little more than half that time, or 3947 days. The W. wind, indeed, prevails more than that from any other cardinal point, but the S.E. prevails above it; for if we do it equal justice with the W., by adding 236 days of E.S.E. which were given to the E., and 250 days of S.S.E. which were given to the S., we find 2474 days of S.E. wind against the 2081 days of W., or 393 days in favour of the S.E. There seems to be a group of years when the S.E. is in excess, and then a group when the W. is so. In the first decade it exceeds the W. very little; in the second a great deal; in the third the W. not only seems to prevail, but the restoration of the intermediate points to the S.E. still leaves it in the minority.

The institution of the Scottish Meteorological Society, and the publication of their reports by their able secretary, Dr Stark, promise to illustrate the meteorology of Scotland; from the great number of observers using similar instruments, placed in similar positions, and at the same hours, thus furnishing excellent means of comparison.

In comparing the climate of Orkney with that of Scotland in general, it would, indeed, be absurd to form a decided opinion from the observations of one year; but it would be as absurd to shut our eyes to the light which they afford us, when they corroborate and illustrate our former observations, and throw much light on other points not previously observed. The difference in the state of the barometer by these tables is too trifling to deserve notice. Orkney was a little below the average for Scotland in 1857, but it was more above it the previous year. The columns for registering thermometers prove the equability of the Orkney climate much more clearly than the previous table of temperature by the common thermometer. It may be seen that in one part of Scotland the greatest heat of summer was 25½° above that of Orkney, and the greatest cold of winter 21° below it, thus showing a much wider range of temperature; but that is not a fair comparison, as it refers to only a single observation at one place only. June, July, and August are, at an average, 7°·6 hotter during the day, and seven months are colder during the night throughout Scotland than in Orkney, while the latter has a smaller daily range of temperature every month, and in June the difference is 10°. By these observations, the temperature of Orkney seems to be about half a degree lower than the other districts; but it was at least equal in 1856. The mean temperature of Orkney for 1857 is proved to be 47°·4 by the entire agreement of the self-registering thermometers,—the dry bulb one, and that 12 inches deep in the soil. The temperature of the deepest spring may also be considered a proof of its correctness, and of that of the mean annual temperature formerly stated; for though it is not much influenced by the remarkable mildness of the latter months of the year, yet it is nearly half a degree higher than the mean annual temperature. The hygrometer, which is Mason's, shows 0°·3 less evaporation in Orkney than in the other districts. In noticing the deductions calculated from Glaisher's tables, we may pass without remark the minute difference in the "dew point," and in the "elastic force of vapour;" but we cannot thus pass the very unexpected result of this first year's observations, that the humidity of the atmosphere in Orkney is exactly equal to the average of Scotland. These islands have always been characterized as damp. The surrounding water led us readily to believe it. Salt and sugar are so apt to become damp, and steel to rust, that few could anticipate such a result. We were, however, in some measure prepared for it, as, during the latter half of the previous year, when these hygrometric observations were first made, the humidity in Orkney was only 84°·1, while the average of Scotland was 84°·8. The quantity of salt in the atmosphere, from the sea spray, may probably account for these effects of humidity. The number of rainy days in Orkney was 198, giving an average of 16 to each month; while in the average of all the districts it was only 163, giving an average of 14 to a month. That the difference should be on this side might be anticipated from the latitude of Orkney, and the peculiarity of its situation; and we believe that this difference will be rather increased than diminished by a long series of observations; for, in 1856 the number was 212 in Orkney, and only 160 over Scotland, giving 52 more to Orkney. The mean pressure of the wind in Orkney seems to have exceeded that in the other dis-

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tricts by a decimal of ·19; but as no anemometer has been used, this can only be viewed as an approximation to the truth.

From observations made at least once a week, and generally more frequently, we find that the mean temperature of the sea for the year is 49°·6, or 2°·2 above that of the air and the soil, and nearly 3° above that of our best springs. It is even above the mean temperature of any year yet recorded, and a little above the mean temperature of the sea around the coast of Scotland. This seems one of the strongest proofs that the Gulf Stream reaches the shores of Orkney, or that some stream from a warmer climate, by whatever name it may be called, raises the temperature of the sea beyond what it could be raised by the power of the sun in Orkney, and higher than it raises the air, the soil, or the springs.

The aurora borealis is sometimes very brilliant in Orkney, and frequently gives more or less light during the winter nights. Sun-pillars are occasionally seen about sunset and sunrise in spring. They were first remarked in 1852, when they were particularly fine, and appeared six times at sunset in April alone.

Water-spouts are very rare. The writer has only seen one, which passed over the sea, about a mile east of Stromness on 12th September 1839, and the upper portion caught his attention in Sandwick, 6 miles off, appearing like a dark funnel-shaped cloud, hanging down from other dark clouds.

The Orkney crops of the more hardy kinds of grain, as oats, bere, and barley, are equal to those of other parts of Scotland. Its potatoes are famous in the southern markets for seed, as the Orkney reds, grown in Orkney, are less apt to take the disease when planted in the south than any other variety; but green crop is that in which it particularly excels. The gardeners are scarcely behind those in the south, for the more hardy kinds of vegetables, fruits, and flowers. Apples do not grow well as standards, but thrive pretty well as wall-trees. Pears and cherries grow, but are not very productive. Black currants thrive even better than in the south. Red and white currants and strawberries grow very well, but gooseberries do not always ripen. All the more hardy annuals and perennials met with in the south also adorn the Orkney gardens.

The history of the islands will not detain us long. They seem to have been originally peopled by a Scandinavian tribe; but little certain is known till the year 870, when the Norwegian chiefs who had fled from home because of the victories of Harold the Fair-Haired, arrived there. Harold pursued them six years afterwards, defeated them, and appointed Ronald, Count of Moere, jarl of Orkney. He was succeeded, after an interval and some changes, by his son Einar; while another son of his, Rolla, wrested Normandy from Charles the Simple, King of France, and, becoming duke of that province, was the great-great-great-grandfather of William the Conqueror. The descendants of Ronald ruled as jarls for more than four hundred years, when the male line terminated in the person of Magnus, the fifth earl of that name. He died about 1325, leaving one daughter, Matilda, who became the wife of Malise, Earl of Stratherne, and had issue Isabell, who married Sir William St Clair, Baron of Rosslyn; and the son of this marriage, Sir Henry, was the first of the *Scottish* earls of Orkney. His title was admitted by Hacon VI., King of Norway, in 1379. By a treaty entered into before this period between the courts of Norway and Scotland, the former ceded to the latter Man and the Western Islands, for the payment of a certain yearly sum called the "Annual of Norway." This tribute, not having been regularly rendered, soon amounted to a large sum; and after much negotiation on the matter, it was arranged that the arrears of the "Annual" should be held as discharged; that James III. should marry Margaret of Norway; that her dowry should be 60,000 florins; and that Orkney should be impignorated to Scotland for five-sixths of that sum—the islands to be redeemed on payment of the money. This treaty was entered into in 1468. The marriage-portion was never paid; and it has given rise to much controversy whether the claim of Norway to these islands has been ever formally relinquished. This is a question that need not be considered here, as it has been for centuries practically resolved. The earldom remained in the family of St Clair till 1471, when it and the title were merged in, or rather were united to, the crown of Scotland, never again to be alienated except in favour of a lawful son of the king. For almost a century the crown lands were leased to various tenants, till at length, in May 1564, Queen Mary granted a charter to Lord Robert Stuart, her father's son by Dame Euphemia Elphinstone, constituting him Earl of Orkney. Afterwards, by her marriage contract with Bothwell, dated May 1567, Mary bound herself to create her husband Duke of Orkney, and to put him in possession of the islands. He appears never to have been infeft, or at all events a month after the marriage he fled, and the dukedom was at an end. Earl Robert had no concern with Orkney from 1567 to 1581; but in the latter year he had another grant of the earldom made to him. This was revoked by King James upon his attaining his majority in 1587. Again a further grant was executed in favour of him and his heirs in 1591, which in 1592 was confirmed by Parliament. Earl Robert died in that year, and the earldom was once more resumed by the crown; and once more, in March 1600, Patrick, son of Robert by the Lady Jean Kennedy, got a grant in his favour; and in May of the same year he obtained a grant of the bishopric. Earl Patrick's many crimes brought him to the scaffold in 1615; and after his death the Orkneys were again unalienably annexed to the Crown, and again they were alienated in 1643. This deed was declared null and void in 1669; and once again, in 1707, they were mortgaged to the Morton family, burdened with an annual payment of L.500 to the crown. In 1742 this mortgage was declared irredeemable; and Lord Morton, in 1766, sold his right for L.60,000 to Sir Lawrence Dundas, in whose family (now Earldom of Zetland) the property still remains.

Orkney Islands.

Of the trade and manufactures of Orkney, it is not easy to give anything like an accurate estimate. In 1853 the number of vessels was 43, and the tonnage 2485. In 1856 there were 48 vessels, and the tonnage amounted to 3039; and this irrespective of a large unregistered flotilla of smaller crafts. The traffic in steam-vessels not entered in the Orkney custom-house is large, and increasing year by year. The tonnage of the coasting trade in 1856 was 27,680 tons imported, and 29,388 exported. The exports consist chiefly of grain, fish, cattle, sheep, butter, hides, &c. Till a recent period, the principal manufacture in the islands was kelp, which at one time brought L.12, L.16, or even L.20 a ton. The greatest quantity ever made in one year was in 1826, when 3500 tons were manufactured, which, on an average, sold at L.7 a ton. In 1837 there were 800 tons of drift-weed kelp made, selling at about five guineas a ton, and 300 tons of cut-weed kelp, averaging per ton half as much.

In 1833 there were forty vessels of about thirty tons, each engaged in the cod-fishery, and they caught and cured about 560 tons of fish. In 1857 there were 318 boats of 10 tons or upwards, and the weight of the fish cured had swelled to 16,424 cwts. In addition to this there were 18 larger vessels, whose united produce amounted to 2731 cwts of salted fish. In 1857 there were 380 herring-boats engaged in that trade; and there were cured and packed on shore 14,075 barrels, besides 700 barrels sold while fresh. During the same year, there were 117 lobster-boats. Sandey furnished the greatest number (23), and Shapinshey the smallest (2). It is estimated that the steamers last year carried from Kirkwall 2703 black cattle, and that 586 went by the sailing-vessels. About 800 went from Stromness.

There are two licensed distilleries in Kirkwall; and in 1857 there were made 11,135 gallons of whisky in Kirkwall, and 5385 in Stromness, yielding, at 8s. a gallon, to the revenue a duty of L.6608.

In conclusion, we would remark, that the improvements introduced during the last twenty, and especially the last ten years, are most striking. In the Mainland and North

Orleans.

Islands more than 4000 acres of waste land are said to have been reclaimed during the last five years. The vast agricultural capabilities of the county are becoming known, and are being rendered available. Draining is extensively resorted to. Roads are being made under the sanction of an act of Parliament. An Orkney man is ceasing to be the amphibious animal his father was. Regard is had to the division of labour. The farmer is contented to plough his fields, leaving it to the fisherman to plough the main. The improvements in progress, and contemplated, will most materially ameliorate and enrich the county.

The lower classes are orderly, industrious, and far from being ill-informed. The upper classes, as a body, are not inferior to their equals in station in any part of Scotland. More frequent intercourse with the mainland of Scotland is rubbing off certain peculiarities; but we rejoice to know that the character which Orkney possesses for kindness, courtesy, and generous attention to strangers, remains unchanged.

ORLEANS, a city of France, capital of the department of Loiret, stands on the slope of a hill on the right bank of the Loire, 34 miles N.E. of Blois, and 68 S.S.W. of Paris. Though large and presenting a fine appearance from a distance, it is, with the exception of a few modern streets, not well built; and has not that bustle and animation which might be expected from its size and population. The river is crossed by a handsome bridge, which was built in 1761. It is 1089 feet long, and consists of 9 arches, the centre one of which has a span of 108 feet. From this bridge the principal street of Orleans extends northwards through the town to the Barrière de Paris, at the most northerly extremity. The length of this street is about three-fourths of a mile; and in the middle of it is the Place du Martroy, of an irregular shape, which contains a bronze statue of Joan of Arc, with four bas-reliefs, also in bronze, representing the principal events in her life. From this to the Loire, the street which is called the Rue Royale, is one of the handsomest in France; the part north of the Place du Martroy, which is called the Rue de Banier, is also a fine street. Another broad street has been opened up through an old and crowded part of the town, leading eastward from the main street to the cathedral, which is the principal building in Orleans, and is thus seen to greater advantage than it could be when blocked up by the surrounding buildings. To these modern streets the more ancient parts of the town present a striking contrast; as the streets in the latter are irregular and ill paved, and the houses for the most part built of wood. The cathedral is remarkable, as having been built in a pure Gothic style in the seventeenth century, at a time when that kind of architecture had entirely fallen into disuse. It was begun by Henri IV. in 1601; but has only recently been finished. The west front is very much admired; it has three pointed portals, and is flanked by two towers of great elegance and beauty, each 280 feet high. Among the other ecclesiastical buildings of the town, the church of St Agnan,—a fine Gothic edifice, that has lost both its nave and steeple,—and that of St Pierre le Puellier, the most ancient in Orleans, possess the most interest. The old town-hall, which has recently been repaired, has long been used as a gallery of paintings and museum of antiquities. The court of justice is a building in the Doric style, with four columns in front. Besides these public buildings, Orleans contains several houses that are interesting from their historical associations. Such are the houses of Joan of Arc, of Francis I., of Agnes Sorel, of Diana of Poitiers; some of which are remarkable for their architecture and ornaments. Orleans also contains a theatre, barracks, prison, hospital, several schools, scientific society, botanic garden, and public library. It is the see of a bishop; and has a court of appeal for three departments, an inferior court, council of *prud'hommes*, and chamber of commerce. There was formerly here a university, at which Calvin, Beza, and other great men studied. The manufactures of Orleans are numerous, but not of very great importance. They consist of woollen and cotton stuffs, hosiery, hats, leather, refined sugar, beer, vinegar, ironmongery, tools of various kinds, earthenware, &c. The trade of the place is extensive; but in recent times has been on the decline. Corn, wine, timber, wool, cheese, and the produce of the manufactures are the chief articles of trade. The situation of the town on the Loire, here navigable for small steamers, and at the junction of three railways, which communicate with Paris, Nantes, Bourdeaux, Lyons, and other places, give Orleans great importance in commerce. Both sides of the Loire are here lined with handsome quays; and on the south bank stands the suburb of Olivet. Besides this, there are numerous other suburbs, and many country houses in the neighbourhood. The old fortifications, which have been levelled with the ground, are now replaced by finely planted public walks. Orleans is generally believed to be the same as the ancient *Genabum*, a town of the Celtic people Carnutes, which was taken and burnt by Cæsar in 52 B.C. It was afterwards called Aureliani, from which the modern name has been derived. In 451 A.D. Orleans was besieged by Attila, but ineffectually, as the place was relieved after a brave defence by Ætius. It subsequently fell into the hands of the Franks, and was made the capital of one of their small kingdoms. Under the Capetian kings, Orleans was one of the most important of their possessions on account of its military strength; and it was only by this town that the French kings exercised any control over the south of France. The most important event connected with Orleans in modern history, is its siege by the English in 1429; and its deliverance by Joan of Arc. She entered the town in spite of the besiegers, and brought a supply of provisions from Blois to the garrison, then sallying out at the head of the French troops, having crossed the river in boats, she led on the attack on a fort erected by the English on the other side. This was compelled to surrender, and on the following day the besiegers destroyed their remaining forts, and raised the siege. In the civil wars of the sixteenth century, Orleans was besieged in 1563 by the Duke of Guise, who was assassinated before the walls; and it suffered much then and subsequently from religious dissensions. Orleans gave the title of Duke to a branch of the family of Valois, to which Louis XII. belonged. Pop. (1856) 43,256.

Orleans || Orley.

ORLEANS, the name of an island in the St Lawrence, Lower Canada, below Quebec. It is 25 miles in length, by 5 in breadth; and being fertile and covered with fine woods, it forms an agreeable place of residence, and is much frequented.

ORLEANS, House of, a branch of the royal family of France. Besides those who succeeded to the king by title, the following are the Dukes of Orleans who play a prominent part in the history of their country. Louis, the second surviving son of Charles V., who was born in 1371, became regent to his brother Charles VI. in 1393, and was murdered by the Duke of Burgundy in 1407; Philippe, the celebrated regent, who was born in 1674, succeeded to the regency after the death of Louis XIV. in 1715, and died in 1723; and Louis Philippe Joseph, the father of the late French king, Louis Philippe, who was born in 1747, renounced his family title for the assumed name of *Egalité*, during the revolutionary turmoils of 1792, and was guillotined in the following year. (See France.)

Orleans, *New*. See New Orleans.

ORLEY, Bernard Van, an eminent painter, was born in Brussels about 1490. After studying at Rome under Raphael, he returned to settle in his native town, bringing back with him much of the taste and the grand style of the Italian masters. In a short time he had risen to professional eminence. Margaret of Austria, the ruler of the

Netherlands, appointed him her painter; he executed several pictures for churches both in Antwerp and Brussels; and his pencil was employed by Charles V. in painting, as cartoons for tapestries, several hunting pieces representing the emperor and his nobles in the Forest of Soignies. At the time of his death, about 1560, his pictures had amounted to a large number. A list of them, and of the places in which they are to be seen, is given in Stanley's enlarged edition of Bryan's *Dictionary of Painters and Engravers*. Two other artists called Orley—namely, Richard Van and Jan Van—were also natives of Brussels.

ORLOFF or ORLOV, GREGORY, a favourite of Catherine II. of Russia, was born in 1734, and having entered the Russian army, served in the Seven Years' War. He had a handsome figure, a genteel bearing, an unscrupulous conscience, and all the other accomplishments essential to a tuft-hunter. Accordingly, he had not been long in St Petersburg when the Grand Duchess Catherine made him her favourite paramour, and her accomplice in her ambitious plots. His fortune rose still higher, when his mistress in 1762 had assassinated her husband, Peter III., and had mounted the throne. Dignities and riches were lavished upon him; he was allowed to wear the picture of the empress in his button-hole; and a medal was struck, and an arch erected in honour of his having stayed a plague at Moscow in 1771. Yet by this time the minion, in his pampered insolence, was bringing about his own disgrace. The proposal of Catherine to marry him privately would not satisfy him. He would be her acknowledged husband and her associate in the throne, or at least he would be made the king of some such country as Astrakhan. This arrogance gradually estranged the empress, until in 1772 she took advantage of his absence, on an embassy to the Turks, to supplant him by a new favourite. From this time Orloff seems to have been the victim of disappointed ambition. Although honoured with the title of prince, supplied with large grants of money, and latterly re-admitted to the court, he could not tolerate the sight of his successful rival. He sought to forget his chagrin in foreign travel. Madness, however, seized him, and brought him to the grave in 1783. Orloff had by Catherine a son named Bobrinski.

ORLOFF, *Alexis*, a brother of the preceding, was born in 1737, and became a soldier by profession. His Herculean strength and stature, and his reckless audacity, rendered him a valuable tool for his brother in the revolution of 1762. He engaged to be one of the assassins of Peter III.; and it is said that it was his hands that strangled the unfortunate monarch. The after services of Orloff in the cause of the Empress Catherine were of the same unprincipled stamp. It is true that in command of the Russian fleet in 1770 he burned the Turkish squadron in the Bay of Tchesme, and thus won many notable honours and the title of Tchesmenski. But most writers attribute his victory entirely to the counsels of the Englishman Elphinstone. He was certainly more in his element when soon afterwards he sought out the youthful Russian princess Tarakanova at Rome, decoyed her on board a vessel, and sent her home to spend her days in a dungeon. The public life of Orloff closed at the death of Catherine and the accession of Paul. After having been compelled to attend at the disinterment, and to assist at the funeral of Peter III., he was glad to escape from further punishment into Germany, and to remain away from Russia till the commencement of the next reign. His death took place at Moscow in 1808.

There were three other brothers who took part in the plots, and shared the prosperity of the two above mentioned.

ORLOP, in nautical language, the lower deck of a ship-of-the-line, or that on which the cables, sails, &c., are stowed.

ORME, ROBERT, author of a History of British India, was born at Anjengo, in Travancore, in 1728. He was educated at Harrow school, and after spending a year in a counting-house in England, he went to Calcutta in 1742, and engaged in commercial pursuits. His energy and intelligence soon attracted notice; and for a number of years he rendered essential service in connection with the government of India. Failing health, however, compelled him to return to England in 1758. He settled in London, and employed himself for the two succeeding years upon his *Military History*. The first volume appeared in 1763, and was received with great approbation. The East India Company not only granted him free access to their records, but appointed him their historiographer, with a salary of L.400 a-year. He was chosen a fellow of the Society of Antiquaries in March 1770; and was on familiar terms with the leading men of his time. After the publication of the second volume of his *History* in 1778, he continued to amuse himself with literary pursuits of a more general nature. In 1792 he retired to Ealing, where he died on the 13th January 1801.

Good sense and sound judgment were the principal features of his mind. His works are more distinguished by simplicity, clearness, and precision, than by any very powerful eloquence, or a very nice discrimination of character. His works are,—*A General Ideal of the Government and People of Indostan*, written in 1752, and printed among his posthumous works; *History of the Military Transactions of the British Nation in Indostan from the year* 1745; the first volume, published in 1763, extends to 1756; and the second, published in 1778, carries the history down to the peace of 1763; *Historical Fragments of the Mogul Empire, from the year* 1659, 8vo, London, 1782; first published anonymously, but acknowledged and reprinted in 4to in 1805, together with the *Origin of the English Establishment at Broach and Surat*, the *General Idea of the Government and People of Indostan*, and a Life of the author. Several hundred volumes of Orme's manuscript collections, together with some scarce printed tracts relating to oriental history, are preserved in the library of the East India Company.

ORMEA, a town of the Sardinian States, division of Coni, on the left bank of the Tanaro, 16 miles S. of Mondovi. It has an ancient castle, and is surrounded by ruinous old walls; the parish church is a large and handsome building. Candles and woollen cloth are made here; there are also saw-mills, and a trade in timber, rural produce, &c. Pop. 4750.

ORME'S HEAD, GREAT, a promontory of Wales, county of Carnarvon, 4 miles N.W. of Conway, forming, along with Little Orme's Head, 4 miles E.S.E., a rocky inlet of the Irish Sea, called Orme's Bay. It consists of a limestone peninsula, 676 feet high, on which stands Llanddudno church.

ORMOND, DUKE OF. See BUTLER, *James*.

ORMSKIRK, a market-town of England, county of Lancaster, 12 miles N. by E. of Liverpool, and 42 S. by W. of Lancaster. It is clean and well built. From the market-place in the centre, in which stands a town-hall, four well-paved streets diverge at right angles. The church, a large building, which was rebuilt in 1729, has a tower and a spire separated from one another. It contains the tombs of the Earls of Derby. There are also places of worship in the town and neighbourhood belonging to Methodists, Independents, Unitarians, and Roman Catholics. Ormskirk has several schools, literary societies, a savings-bank, dispensary, almshouses, &c. The place is famous for the gingerbread made here; but the chief occupations of the people are handloom-weaving, rope-making, and brewing. Near this place, in 1644, the Royalists were defeated by the Parliamentary troops with great slaughter. Pop. (1851) 5548.

Ormuz || Orne.

ORMUZ, or HORMUZ, a small island at the mouth of the Persian Gulf, near its northern shore; N. Lat. 27. 5., E. Long. 56. 29. It is about 10 miles distant from the continent, a rugged, bare, and sterile rock, without any vegetation, and about 12 miles in circumference. It has several high peaks covered with a transparent ice-like incrustation of salt. Other parts of the island consist of soil of a dark red colour produced by the oxide of iron, with which the whole is impregnated; while other portions are yellow with sulphur, or grey with copper. The shape and geological structure of the peaks seem to indicate that it is of volcanic formation. Of the town on the northern side, which once contained about 40,000 inhabitants, nothing now remains but a mass of scattered ruins; among which the remains of aqueducts and walls still attest its former greatness. There is, however, a good harbour and a fort, which stands on a promontory separated from the island by a moat. Ormuz was taken possession of by the Portuguese in 1507; and was made by them an emporium for the trade of India and the East. It thus became a place of deposit for the valuable products of India, the jewels of Bokhara, and the manufactured goods of Europe and Asia. The town speedily rose, and the island attained to great importance under the Portuguese sway. It is to this period of its prosperity that Milton refers, when he speaks of the wealth of Ormuz in these lines:—

> "High on a throne of royal state, which far
> Outshone the wealth of Ormuz and of Ind;
> Or where the gorgeous East, with richest hand,
> Showers on her kings barbaric pearl and gold,
> Satan exalted sat."—*Paradise Lost*, b. ii.

It was taken from the Portuguese, and the town was demolished, in 1622, by Shah Abbas, King of Persia, assisted by a British squadron of ships. On the introduction of the Mohammedan religion into Persia, the disciples of Zoroaster took refuge in the rocky caves of Ormuz; whence they emigrated to Bombay, and now form the people called Parsees. The island still belongs to Persia; but it is rented by the Imam of Muscat, who keeps a small force here to defend the fort and harbour. There are no springs of fresh water in the island, which is supplied by rain water caught in reservoirs made by the Portuguese.

ORNE, a department of France, lying between N. Lat. 48. 12. and 48. 58., E. Long. 1. 0., and W. Long. 0. 47. It is bounded on the N. by the department of Calvados, E. by those of Eure and Eure-et-Loire, S. by Sarthe and Mayenne, and W. by Manche. Its length from E. to W. is 84 miles; breadth, on an average, 28 miles; area, 2346 square miles. It is crossed from E. to W. by a chain of hills, which separate the waters of the Loire from those of the English Channel. The highest summits of these hills are only about 1368 feet above the level of the sea. The principal rivers are,—the Orne, from which the department takes its name, the Toucques, and the Dives, all flowing northwards from the hills into the English Channel; the Huine, Sarthe, Varenne, and Mayenne, which flow to the south, and discharge their waters into the Loire. None of the rivers are navigable in the department. Orne contains numerous lakes; but they are all small and insignificant. The character of the surface and of the soil is very various in different parts, bearing in some places evident traces of volcanic action. The extent of arable land in the department is 822,890 acres; of meadows, 323,730 acres; of wood, 177,922 acres; and of waste land, 42,318 acres. The state of agriculture is not very highly advanced, and the arable land is not of any great fertility; so that notwithstanding its extent, the quantity of corn produced falls short by about a third of the demands of the population. Oats, buckwheat, potatoes, rye, hemp, and flax, are the principal crops raised; in some places also beetroot is grown for the manufacture of sugar. The climate of Orne is temperate, but very damp; in spring and autumn much rain falls; and though the summer is mild and dry, during the winter snow, rain, and foggy weather prevail almost without intermission. No wine is made in this country; but there are very many apple and pear trees, in many places lining the roads, and affording quantities of cider and perry, the favourite beverages of the inhabitants. The pastures are very good, and many cattle from the neighbouring departments are sent here to be fattened. They, as well as the sheep of Orne, are numerous and of good breed; the horses also, especially those of the plain of Alençon, being of the purest Norman breed, are highly esteemed. The department contains about 135,000 head of cattle, 215,000 sheep, 30,000 pigs, 52,000 horses, &c. Iron mines are worked in some parts of the department, and among the mineral productions are granite, marble, building stone, porcelain, clay, &c. The principal branches of industry carried on are the working of iron and the weaving of cloth; there are 49 smelting furnaces and forges for iron, besides cutleries, needle-manufactories, and establishments for making cloth, paper, glass, and lace which is highly esteemed. The articles of commerce, besides the produce of the manufactures, consist of corn, honey, cider, flax, wax, horses, cattle, poultry, timber, &c. The department forms part of the diocese of Séez; and for public instruction contains 4 colleges, a normal school, 3 upper communal schools, and 623 elementary schools. The capital is Alençon, and the department is divided into four arrondissements as follows:—

Orne.

	Cantons.	Communes.	Pop. (1856.)
Alençon	6	95	72,492
Argentan	11	191	102,074
Domfront	8	93	137,392
Mortagne	11	155	118,169
Total	36	534	430,127

ORNE, a river of France, giving its name to the above department, in which it rises, not far from Séez. It flows northwards to the borders of the department of Calvados, then turns N. by E., and falls into the English Channel, after a course of 90 miles. It receives the Noireau, the Aize, and the Oden, and is navigable as far as Caen, 10 miles from its mouth.

ORNITHOLOGY.

History. ORNITHOLOGY, from ὄρνις, *bird*, and λόγος, *discourse*, is that department of Zoology which treats of the history and attributes of the feathered race. Birds form the second great division of the animal kingdom, being usually placed immediately after the Mammalia, and antecedent to the reptile class. They may be defined as vertebrated, oviparous animals, covered with feathers, organized for flight, and enjoying a double system of circulation and respiration; that is, their whole blood, like that of quadrupeds, must visit the lungs and return to the heart before it is propelled to the extremities,—and the entire system is provided with reservoirs of air, in addition to the lungs properly so called.

The vast extent which the science of Ornithology has acquired in recent times renders a full exposition impossible within our necessarily prescribed limits; but we shall endeavour at least to indicate the majority of the more important groups, to figure and describe in each some interesting species, and by frequent reference to such authors as have most successfully treated of the different branches in detail, enable such of our readers as desire a more elaborate view, to follow out the subject for themselves. We presume it matters not with which department we commence. Let us begin, then, with the Bibliography, which, however, need not detain us long.

Few if any important works have been transmitted to us from antiquity. In the third book of Aristotle's History of Animals (Περὶ Ζωων Ἱστορία, the period being about 350 years before the Christian era) we find recorded sundry observations, but brief and superficial, on the feathered race.[1] His division seems to be into such as have hooked claws, such as have separated toes, and such as are web-footed; and he observes, that the first have the breast the most robust. He describes the differences in the structure of the feet, and notices, that although the generality have three toes in front, and one behind, yet a few have only two toes in front. The bill supplies the place of lips and teeth, and passages in different parts of the head supply the place of the external organs of the senses of smell and sound. The eyes are furnished with a membrane like that possessed by lizards, but want eyelashes. No bird with hooked claws has likewise spurs upon its legs. These are a few examples of Aristotle's style of observation on the class in question.

Pliny was born about the twentieth year of the Christian era. The tenth book of his *Historia Naturalis* treats in part of birds, but in a very meagre and immethodical manner. He tells us of the raven and the phœnix, of the owl, the ibis, and the nightingale, of capons, and the cock-fights of Pergamus, and of the character and conduct of various other birds.

For 1500 years from the time of Pliny we have no recorded observations on Ornithology deserving of the reader's recollection. About the middle of the 16th century Conrad Gesner, a native of Zurich, and a noted Frenchman called Pierre Belon, each published works in part devoted to Ornithology. The writings of Gesner (*Historia Animalium*, 3 vols. folio) exhibit a cumbrous erudition, with a sprinkling of original observation, but are chiefly extracted from ancient authors. Baron Cuvier regarded him as an excellent compiler. His arrangement is alphabetical. Belon's most successful efforts were in the ichthyological department, but even in his *Historia Avium*, History. 1 vol. folio, 1551, we may trace an improved spirit of observation, although the basis of his classification would scarcely suffice to support a system now-a-days. He divides the class of birds into six primary divisions. 1*st*, The birds of prey, among which, misled probably by some false analogy of plumage, he includes the cuckoo. 2*d*, The Palmipedes. 3*d*, The Grallæ, including, however, the king-fisher, bee-eater, and other anomalous species. 4*th*, All the species which place their nests upon the ground, —an extraordinary bond of union, which of course brings together the pheasant, the lark, and the woodcock. Nevertheless, our author does not confound them in his lesser groups. 5*th*, The omnivorous and insectivorous birds, among which are placed the pigeons. 6*th*, The insectivorous and granivorous species, which habitually frequent shrubs and hedges.

Another noted writer of the sixteenth century was Ulysses Aldrovandi of Bologna, whose works amount to thirteen volumes folio;—the majority of them, however, were not published till after his death in 1606. The first three, which treat of birds (as well as one on insects), made their appearance in his lifetime, that is, from 1599 to 1603. They contain some amusing information, amid a vast mass of learned rubbish borrowed from his predecessors. Professor Savi, however, characterised the ornithological portion as "un monumento glorioso del suo instancabile zelo, delle sue estese cognizioni ornithologiche, e della sua universale erudizione." It is at the same time entirely deficient in scientific precision, and contains, amid much truth, a sad intermixture of unmeaning fable. The edition with which we are best acquainted is that of Bologna, 1634.

About nearly the same period a treatise was published by Gommer de Luzaney, with the title of *De l'Autourserie*, which contains some good figures of the birds of prey used in falconry. One of the earliest sketches of the history of European birds is that given by Schwenkfeld, a Prussian naturalist, in a volume entitled *Theorio-Tropheum Silesiæ*, 1603. The arrangement is alphabetical. Olina's *Uccelliera*, which contains tolerable figures of a few species not previously published, appeared at Rome in 1622. It is a small affair, restricted to the description of very few species, but contains accurate and interesting records of their history and mode of capture, as practised by the Italians, with whom *la caccia*, very different from that of Melton Moubray, is a noted passion. A swarthy, fire-eyed hunter of sixty-five is as proud of a string of dead linnets as any young Scotchman of sixteen may be of his first well-filled bag of grouse or black game.

We have next a dissertation on storks, cranes, and swallows, by J. G. Swalbacius (Spire, 1630); a natural history of Nurenberg (Antwerp, 1633); a description of the birds of the West Indies, by De Laet (Leyden, same year); a history of the birds of Brazil, by Marcgraaff (in his *Hist. Rerum Nat. Brasiliæ*, Amsterdam, 1648); and of those of Mexico, by Hernandez (in his *Nova Plant. Animal. et Min. Mexicanorum Hist.* Rome, 1651). A Scoto-Pole of the name of Johnston published about this period (some years elapsing during the completion of the various parts) his *Historia Animalium*, of which the second portion treats of birds. He is a follower, not so much of nature, as of Belon, and other authors of the pre-

[1] As in some of our preceding treatises on Natural History in this work (see, for example, the article MAMMALIA, vol. xiv. p. 121) we have entered at greater length into the general character of the most ancient writers, our present notices are therefore extremely slight.

History. ceding century, and was himself followed by Ruysch, whose *Theatrum Universale Animalium Omnium* may be regarded as a second edition of Johnston's work. The *Natural and Medical History of the East Indies*, by Bontius, appeared in 1658, and contained descriptions of various birds at that time new. Soon afterwards Perrault, Borrichius, and Bartolinus, began to furnish the earliest modern contributions to the *anatomy* of the feathered race.

Willughby's *Ornithologia* (a posthumous work, believed to have been greatly amended and increased by Ray) was published in 1676. The first edition is in Latin, but an English translation, enlarged, made its appearance two years after. Ray's own *Synopsis Methodica Avium* (*et Piscium*) was likewise published posthumously, under the care of Dr Derham, in 1713. The writings of these authors are remarkable, as manifesting an approach to a more natural system of arrangement than had hitherto prevailed; but as they have been so frequently analysed, we deem it unnecessary to occupy our space with any detailed exposition of their views. Baron Cuvier has termed Ray "le premier véritable méthodiste pour le règne animal, guide principal de Linnæus dans cette partie." In Sir Hans Sloane's *Voyage to Jamaica*, &c. (1707–25), we have notices of various birds, accompanied by rather poor engravings; but the work was of great use to science in England, by the attention and emulation which it excited in regard to natural objects, of which the author had brought together upwards of 36,000, besides 200 volumes of preserved plants. His collections formed the original basis of the British Museum. A showy but inaccurate work by Marsilli (1726) is devoted to an interesting subject, the birds of the banks of the Danube. Albin's *Natural History of Birds*, in 3 vols. 4to (1731–38), contains above three hundred coloured figures of no great merit. Yet it was afterwards reprinted in French, with additions, at the Hague. About the same period was published Catesby's *Natural History of Carolina, Florida, and the Bahama Islands*, in 2 vols. folio, and appendix (1731–43), with numerous coloured plates of birds and other beings. Frisch's excellent work on German birds (*Vorstellung der Vogel Deutschlands*) was commenced at Berlin in 1734, and was not completed when the author died. It was continued by a stranger, and a collected edition of the whole work, with two hundred and fifty-five plates, was published in 1763. Although by no means highly finished, these engravings are accurate, and exhibit a good deal of the truth of nature. The arrangement is defective, and retrogrades from that of Ray. Seba's great, or rather large work, the *Locupletissimi rerum naturalium Thesauri accurata descriptio*, was being carried on during this period at Amsterdam, in four volumes folio (1734–65). It is unworthy of being quoted, except in reference to the plates.

By this time the illustrious reformer of systematic natural history had made his appearance as an author; the first edition of the *Systema Naturæ*, consisting of only fourteen pages folio, having been published at Leyden in 1735, when Linnæus was not more than eighteen years of age. It ran through twelve editions in little more than thirty years; the twelfth impression, the last which the author could himself revise, appearing at Stockholm in 1766–68. The influence exercised by the writings of the great Swedish naturalist is too important to admit of our proceeding farther without exhibiting a view of his classification, so far at least as concerns the feathered race. The following table presents an outline of the Linnæan arrangement of birds, which he divides into six primary groups called orders.

Order I. Accipitres, or *birds of prey*. The bill more or less curved, the upper mandible dilated, or armed with a tooth-like process near the tip; the feet short, robust, with acute hooked claws. History.

Genus *Vultur*. Vultures. Beak hooked; head bare: eight species.

Falco. Eagles and hawks. Beak hooked; head feathered: thirty-two species.

Strix. Owls. Beak hooked, feathers at its base directed forwards: twelve species.

Lanius. Shrikes. Beak straightish, notched: twenty-six species.

Order II. Picæ. The bill cultriform, with the back convex; the feet short, rather strong.

Genus *Psittacus*. Parrots. Beak hooked; upper mandible furnished with a cere: forty-seven species.

Rhamphastos. Toucans. Beak very large, hollow, convex, serrated; both mandibles incurved at the tip: eight species.

Buceros. Hornbills. Beak convex, curved, cultrate, large, serrated; forehead covered by a horny plate: four species.

Buphaga. Beef-eaters. Beak straight, somewhat quadrangular; the mandibles bulging: one species.

Crotophaga. Plantain-eaters. Beak compressed, half egg-shaped, arched, keeled on the back: two species.

Corvus. Crows. Beak convex, cultrate; nostrils covered by recumbent bristly feathers: nineteen species.

Coracias. Rollers. Beak conical, convex, straight, acute; upper mandible slightly longer, and indistinctly notched: twenty species.

Gracula. Grakles. Beak cultrate, convex, somewhat bare at the base: eight species.

Paradisea. Birds of Paradise. Beak covered with the downy feathers of the forehead; feathers of the sides long: three species.

Trogon. Curucuis. Beak shorter than the head, cultrate, hooked, serrated: three species.

Bucco. Barbets. Beak cultrate, laterally compressed, notched at the tip, incurved, opening to beneath the eyes: one species.

Cuculus. Cuckoos. Beak roundish; nostrils with a prominent margin: twenty-two species.

Yunx. Wrynecks. Beak roundish, sharp pointed; nostrils concave: one species.

Picus. Woodpeckers. Beak angular, straight, the tip wedge-shaped; the nostrils covered with recumbent bristly feathers: twenty-one species.

Sitta. Nut-hatches. Beak awl-shaped, roundish, straight: three species.

Todus. Todus. Beak awl-shaped, a little flattened, obtuse, straight, with spreading bristles at the base: two species.

Alcedo. King-fishers. Beak three-cornered, thick, straight, long: fifteen species.

Merops. Bee-eater. Beak curved, compressed, keeled: seven species.

Upupa. Hoopoes. Beak arcuate, convex, a little compressed, rather obtuse: three species.

Certhia. Creepers. Beak arcuate, slender, acute: twenty-five species.

Trochilus. Humming-birds. Beak slender, longer than the head, its tip tubular: twenty-two species.

Order III. Anseres. Web-footed water-fowl. Bill smooth, covered with epidermis, enlarged at the tip; the toes united by a web, the legs compressed and short.

Genus *Anas*. Swans, geese, ducks. Beak lamellated at the margin, convex, obtuse: forty-five species.

History. Genus *Mergus*. Mergansers. Beak denticular cylindrical, the tip hooked: six species.

Alca. Auks. Beak short, compressed, convex, furrowed, the lower mandible with a prominent angle: five species.

Procellaria. Petrels. Beak a little compressed; the upper mandible hooked, the lower channelled and compressed at the tip: six species.

Diomedea. Albatrosses. Beak straight; upper mandible hooked at the tip, lower abrupt: two species.

Pelecanus. Pelicans, solan-geese, cormorants. Beak straight, the tip hooked, unguiculate: eight species.

Plotus. Darters. Beak straight, sharp-pointed, denticulate: one species.

Phaeton. Tropic birds. Beak cultrate, straight, acuminate: two species.

Colymbus. Divers. Beak slender, straight, sharp-pointed: eleven species.

Larus. Gull. Beak straight, cultrate, the tip slightly hooked, the lower mandible with an angular prominence: eleven species.

Sterna. Terns or sea-swallows. Beak slender, nearly straight, acute, compressed: seven species.

Rynchops. Skimmers. Beak straight; upper mandible much shorter, lower abruptly terminated: two species.

ORDER IV. GRALLÆ. *Waders or shore-birds*. Bill somewhat cylindrical; the feet long, bare above the tarsus, and formed for wading.

Genus *Phœnicopterus*. Flamingoes. Beak incurvated as if broken, denticulate; feet webbed: one species.

Platalea. Spoon-bills. Beak flattish, the tip dilated, rounded, and flat: three species.

Palamedea. Screamers. Beak conical; the upper mandible hooked: two species.

Mycteria. Jabiru. Beak acute; lower mandible trigonal, ascending; upper three-cornered, straight: one species.

Cancroma. Boat-bills. Beak bulging; the upper mandible resembling a boat with the keel uppermost: two species.

Ardea. Herons and cranes. Beak straight, acute, long, a little compressed, with a furrow from the nostrils to the tip: twenty-six species.

Tantalus. Ibis. Beak long, slender, arcuate; face bare: seven species.

Scolopax. Snipes and curlews. Beak long, slender, obtuse; face feathered: eighteen species.

Tringa. Sand-pipers, or shore-larks. Beak roundish, as long as the head; nostrils linear; feet with four toes: twenty-three species.

Charadrius. Plovers. Beak roundish, obtuse; feet with three toes; twelve species.

Recurvirostra. Avosets. Beak slender, recurved, pointed, the tip flexible: one species.

Hæmatopus. Oyster-catchers. Beak compressed, the tip wedge-shaped: one species.

Fulica. Coots. Beak convex; upper mandible arched over the lower, which has a prominent angle: seven species.

Parra. Jacanas. Beak roundish, rather blunt; forehead wattled; wings spurred: five species.

Rallus. Rails. Beak thicker at the base, compressed, acute: ten species.

Psophia. Trumpeter. Beak conical, convex, rather sharp; the upper mandible longer: one species.

Otis. Bustards. Beak with the upper mandible arched: four species.

Struthio. Ostrich and cassuary. Beak somewhat conical; wings unfit for flying: three species.

ORDER V. GALLINÆ. *Poultry* and other *gallinaceous birds*. Bill convex, the upper mandible arched over the lower, the nostrils arched with a cartilaginous membrane. Feet with the toes separated, and rough beneath. History.

Genus *Didus*. Beak contracted in the middle, with two transverse rugæ; the tip of both mandibles bent inwards: one species, now extinct.

Pavo. Pea-fowl. Head covered with feathers, those of the rump elongated, with eye-like spots: three species.

Meleagris. Turkeys. Head covered with spongy caruncles; the throat with a longitudinal membranous wattle: three species.

Crax. Curassoes. Beak with a cere at the base; head covered with recurved feathers: five species.

Phasianus. Domestic fowls and pheasants. Sides of the head bare: six species.

Numida. Guinea-fowls. Carunculated wattles on each side of the face; head with a horny crest: one species.

Tetrao. Grouse and partridges. Bare papillæ near the eyes: twenty species.

ORDER VI. PASSERES. *Passerine birds, and others*. Bill conical, sharp pointed; feet slender, the toes separated.

Genus *Columba*. Pigeons. Beak straight; nostrils with a tumid membrane: forty species.

Alauda. Larks. Beak slender, pointed; tongue slit; hind claws very long: eleven species.

Sturnus. Starlings. Beak slender, pointed; flattened towards the point: five species.

Turdus. Thrushes. Beak subulate, compressed, notched: seven species.

Ampelis. Chatterers. Beak awl-shaped, depressed at the base, notched: seven species.

Loxia. Gross-beaks, bullfinches, &c. Beak conical, bulging at the base: forty-eight species.

Emberiza. Bunting. Beak somewhat conical; lower mandible broader: twenty-four species.

Tanagra. Tanager. Beak notched, awl-shaped, conical at the base: twenty-one species.

Motacilla. Wagtails and warblers. Beak awl-shaped; tongue jagged; claw of the hind toe of moderate length: forty-nine species.

Pipra. Manakin. Beak awl-shaped, feathers at its base directed forwards; tongue abrupt: fourteen species.

Hirundo. Swallows. Beak very small, depressed at the base, incurved; the mouth wider than the head: twelve species.

Caprimulgus. Goat-suckers. Beak very small, incurved, depressed at the base; large bristles; the mouth very wide: two species.

The amount of species in the class of birds with which Linnæus had to form his system did not greatly exceed *nine hundred*. Yet with what admirable tact has he seized upon the characteristic forms which so long served as the nuclei around which so many other species were assembled! It is true that his arrangement, like all other inventions of human genius, is liable to many objections, and may not suit the subject in the wide extent acquired in recent times;—but when we see how closely his ordinal divisions accord even with the most elaborate arrangements of modern days, and how gracefully his generic groups may now be formed into more extended families, each retaining such strong affinities in its constituent parts, we the more incline to marvel at the two following circumstances;—1*st*, That Linnæus himself should have so far advanced before his age, and anticipated the labours of posterity: 2*d*, that that posterity, or such portion of the same as in-

History. cline not seldom to sneer at his unprecedented and even now unequalled labours, should not perceive that it is to his system they are indebted for almost all that is of any value in their own. But on this subject we shall not here enlarge.

It has been sometimes remarked, that the characters given by Linnæus to his orders are totally inapplicable to many of the species which each contains. Thus the vultures, it is said, which belong to the first order, have no projecting processes on the upper mandible; the parrots, which are referred to the second, have the bill hooked, not cultriform, and bear no resemblance to the other species; among the Anseres, which are characterised as having the bill smooth, covered with epidermis, and enlarged at the tip, are the gannets, with a bare and pointed bill, and the divers, terns, and gulls, with bills not at all answering to the description given; among the Grallæ, with a cylindrical bill, are the ostrich, with a short depressed one, the canchroma, with one resembling a boat, the spoon-bill, the heron, the flamingo, and others, the bills of which differ from each other as much as from those of the snipes and curlews; the character given to the bill of the Gallinæ agrees with that of many Passeres; and the wag-tail, the swallow, the tit-mouse, the red-breast, and numerous other small birds, have bills very different from those of the gold-finch, bunting, bullfinch, and cross-bill, which, nevertheless, are all defined under the same order, and by a similar phrase.[1] We believe the truth to be, that the more natural an order is, the greater the difficulty becomes of expressing its characters in a single line, in accordance with the briefness of the Linnæan method,—because none of these characters, taken in disconnection, remain unmodified throughout the extended series of beings which they are intended to define. There is always a blending or transition towards other groups, so that the character expressed in words must be regarded as applying in force rather to certain species which exemplify the whole, and towards which the others *tend*, than to the entire assemblage. Now the Linnæan genera are often natural as family groups, though their constituent portions may not accord with the definition; and as they become extended, or rather filled up, by the discovery of new species, the difficulty increases. Many of the modifying species, or connecting links, were totally unknown in the time of the great Swedish observer, who seized chiefly upon the more prominent and tangible points; and the necessity of forming new subdivisions in no way invalidates his claims upon the gratitude of all lovers of the *lucidus ordo*. At the same time his early disciples erred (though less grossly than many of the later renegades) in viewing all living things as merely destined to clothe with flesh and blood the gigantic frame-work which he had erected,—as if his exposition of the system of nature were in fact itself that system,—as if the highest attainments of any one, however gifted, in either art or science, were ever more than the passionate expression of some dim vision of truth, perceived through the influence of the love of knowledge. With all the lights of modern method, and the vaunted improvements in classification, see we not still "through a glass darkly?" Have not some of those who talk slightingly of the Swedish sage never contrived to see through the glass at all?

During the thirty years which elapsed between the first and twelfth editions of the *Systema Naturæ*, several important additions were made to Ornithology from other quarters. Edwards, especially, in his *Natural History of Birds, and other rare undescribed Animals*, and in his *Gleanings in Natural History*, amounting in all to seven volumes 4to (1743 and after years), made known in a rough but recognisable style, many new and interesting species. "C'est le recueil," says Cuvier, "le plus riche pour les oiseaux après les planches enluminées de Buffon." During the same period a letter was published at Pappenheim, on the birds of the Black Forest, by J. H. Zorn, *Epistola de Avibus Germaniæ, præsertim Sylvæ Hercyniæ*, which contains many excellent observations; and the correspondence was afterwards extended by Brückmann in his *Aves in Germania obviæ Epistolar. Itinerar.* cent. ii. epist. 18, and *Aves Sylvæ Hercyniæ*, ibid. epist. 17. In Anderson's *Natural History of Iceland and Greenland* (1750), we have among the earliest authentic notices of the Zoology of these northern regions. Klein and Maering each published systematic works, but based on very artificial principles, at this epoch. In Brown's *Civil and Natural History of Jamaica*, there are several ornithological contributions; and we may here name another excellent English work, Borlase's *Natural History of Cornwall*, which appeared at Oxford in 1758. In 1760 Brisson published his great systematic *Ornithologie*, in six volumes 4to, still of value for the minute though laborious exactness of the descriptions. His method is founded entirely on the form of the bill and feet, the number of the toes, and the manner in which these are united, with or without membrane, to each other. The *Ornithologia Borealis* of Brunnich appeared at Copenhagen in 1764.

The *Storia Naturale degli Uccelli*, printed at Florence in 1767, is the most extensive of all the Italian works on Ornithology, after that of Aldrovandi. It is frequently named by Temminck and other modern writers, most of whom, however, from their vague references, may be safely inferred to quote at second hand. It consists of a large collection of plates both of indigenous and exotic birds, executed with sufficient exactness, considering the slight practice which obtained in those days in the representation of natural objects. The position of most of the figures, as Signor Savi remarks, is forced and unnatural; and we may see at once that the artist was guided more by his own fancies than the accustomed observance of living nature. "Illuminatio non semper optima, nec optimus semper avium situs," are the observations made by Bœhmer.[2] The plates were engraved from drawings in the collection of a Florentine patrician, the Marchese Giovanni Gerini, a passionate lover of Ornithology, who passed much of his time in collecting, and causing to be described and figured, whatever birds he could procure from every clime and country. After his death some learned men, unfortunately not much skilled in Ornithology, supposing either that general erudition might suffice for science, or that the superficial study of a few books might compensate the want of laborious observations carried on from year to year, undertook to publish Gerini's uncompleted work, to fill up the voids which he had left, and even to alter what he had already done. They thus compiled a superficial text, in which they confused the classification, mistook the species, omitted several of the most interesting, and neglected the localities,—so that a work which, in the hands of an able editor, might have added a new glory to the already illustrious literature of Italy, became nothing more than a disorderly collection of figures. It is, however, of some value, chiefly as containing representations of species not previously known, such as *Falco cenchris, Fringilla cisalpina, Sylvia provincialis, melanocephala*, and *melanopogon, Sterna leucoptera*, &c.

From the year 1767 onwards, Pallas, in his *Spicilegia Zoologica*, the narrative of his various *Travels*, and the *Acta* of the Royal Academy of St Petersburg, contributed to Ornithology, as to most other branches of zoological science;

[1] Macgillivray's *Lives of Zoologists*, vol. i. p. 279.

[2] *Bibliotheca Scriptorum Historiæ Naturalis*, &c. tom. iii. p. 502.

History. and about the same time the industrious Pennant was actively engaged in his important labours. His numerous well-known works need not be here particularised. The great collection published at Nuremberg by Schligmann in 1768, though amounting to nine volumes folio, including an indifferent text, seems chiefly copied from preceding works, such as those of Catesby and Edwards. In 1770 and following years, Noseman, in conjunction with Sepp the engraver, published, in Dutch, his *History of the Birds of the Low Countries.* The concluding fasciculi are by Houttuyn. Baron Cuvier thinks the figures "remarkable for their elegance." Mr Swainson regards them as "poor and unnatural." The year 1770 is farther marked as an important epoch, by the appearance of the first two volumes of the *Histoire Naturelle des Oiseaux*, by Buffon. That illustrious writer was the first to clothe the descriptive portion of the science with colours as bright and varied as those which beautify the fairy forms of which he treats, but which had hitherto been viewed as it were only by the half-closed eye of the technical describer. The *Planches Enluminées*, afterwards published by Daubenton the younger, in illustration of Buffon's work, amount to above a thousand plates of birds, being the greatest and most important collection yet achieved in this department. In 1774 we have the *Elementa Ornithologica*, by Schœffer, whose system rests entirely on the legs and feet of birds, the primary sections being divided into *nudipedes* and *plumipedes*, while the orders and genera are determined by the number, position, and connection of the toes. He never employs the bill when he can help it; from which we may infer the nature of the work, and its probable utility to the student.

The *Voyages aux Indes*, &c. by Sonnerat (1775 and succeeding years), contains figures and descriptions of many new exotic species. Scopoli's *Introductio ad Historiam Naturalem*, published at Prague in 1777, exhibits a systematic distribution of birds, based on the form of the scales which cover the tarsi. Thus the species which, like the generality of the accipitrine kinds, parrots, the gallinæ, grallæ, and palmipedes, have those parts covered by small polygonal scales, form the section called *retepedes;* while the others, which have the tarsi protected in front by semicircular plates, bordered behind on each side by a longitudinal furrow, constitute the *scutipedes.* The general result, however, of this view is by no means successful. In 1776 Francesco Cetti published his *Uccelli di Sardigna*, a small octavo volume, containing descriptions of only a portion of the Sardinian birds, but valuable, from its notices of their habits, and the description of various new species.

Latham's *General Synopsis* commenced in 1781. However faulty in relation to the present state of the science, it was a work of great merit for its time, and contains, under not very appropriate names, by no means inaccurate descriptions of many rare birds, some of which have since been published, by more recent writers, as entirely new. Under this head we may mention both the *Index Ornithologicus* of the same author (1790), and his greatly enlarged and more modern work, the *General History of Birds*, ten volumes 4to, 1821–24, which combines the two preceding (with their supplements); but is, we regret to say, a mere combination of those rather obsolete materials, without critical discrimination, or any correction of the ancient errors. There is great increase without much progression. Nearly contemporaneous with Latham's first work, we find contributions to Ornithology by Gilius, Merrhem, and Jacquin. About 1783 Mauduit commenced the Ornithology of the *Encyclopédie Méthodique*, for which Bonnaterre formed the system of classification which accompanies the volume of indifferent plates. Of the descriptive portion an excellent modern continuation, if not completion, has been published by M. Vieillot, in three volumes 4to, 1823. Sparmann, a pupil of Linnæus, and a well-known traveller, published in 1786 the *Museum Carlsonianum*, in which several new species are represented and described. In 1787 R. L. Desfontaines (in the *Mémoires de l'Académie des Sciences*) contributed some notices of birds which frequent the coasts of Barbary; and, in the same year, Martinet, who had acted under the younger Daubenton as a superintendent of the *Planches Enluminées*, took it into his head to publish, on his own account, a collection of figures and descriptions of birds, amounting to no less than nine volumes octavo. Their number was not more alarming than their nature. History.

In 1789 and following years, J. F. Gmelin published the thirteenth edition of the *Systema Naturæ* of Linnæus. "Son travail," says Baron Cuvier, "tout indigeste et dénué de critique et de connaissance des choses, est cependant nécessaire, comme la seule table un peu complète de ce qui à été fait jusque vers 1790." About a volume and a half is devoted to Ornithology. White's *Journal of a Voyage to New South Wales* appeared in 1790, forming an interesting addition to the natural history of a country which still offers a vast field for zoological research; and soon afterwards Shaw announced his *Zoology of New Holland*, which advanced no farther than a few fasciculi. We have likewise in 1790 the *Fauna Gröenlandica* of Otho Fabricius, a work of great merit for the time, and still holding a high place in the estimation of the naturalist, from the accuracy of its descriptions, although in some instances the names are misapplied. In 1792 M. Beseke published in German his materials for the *Natural History of the Birds of Courland.* The works by Lord, Hayes, Lewin, and others, which appeared about this epoch, in illustration of the birds of Great Britain, were so soon afterwards superseded by the admirable and unequalled wood engravings by the inimitable Bewick, that it is scarcely necessary to bring their names to the reader's recollection. We may close our imperfect sketch of the Ornithology of the eighteenth century by the mention of Cuvier's first work, the *Tableau Elémentaire d'Histoire Naturelle* (1798), which contains the methodical distribution of birds, which he afterwards completed in his *Règne Animal.*

We may commence the present century with the title of Daudin's work, the *Traité Elémentaire et complet d'Ornithologie*, two vols. 4to, 1800. It is an unfinished compilation, of no great merit, containing only the accipitrine birds, and a portion of the Passeres. Although Le Vaillant commenced his magnificent series of ornithological illustrations during the preceding season, and continued them at intervals for several years, we shall here group together the most important, for the convenience of the reader: 1st, *Histoire Naturelle des Oiseaux de l'Afrique*, six vols. 4to, 1799–1800. The plates amount to 300, but are inferior to those of the other works of the same author. 2d, *Histoire Naturelle d'une Partie d'Oiseaux Nouveaux et Rares de l'Amérique et des Indes*, one volume 4to, 1801. This volume illustrates the *Buceridæ* or horn-bills, and the *Ampelidæ* or fruit-eaters. 3d, *Histoire Naturelle des Perroquets*, 2 vols. 4to, 1801–5. Almost all the plates (139 in number) of this exquisite work are from drawings by Barrabaud, an almost unrivalled artist in the ornithological department. 4th, *Histoire Naturelle des Oiseaux de Paradis, et des Rolliers, suivie de celle des Toucans et des Barbus*, 2 vols. folio, 1806. "Equally splendid," says Mr Swainson, "with the preceding. The size and extraordinary plumage of the paradise birds require a scale fully equal to the dimensions of this volume, which exceeds any other of the author's in the beauty and splendour of its contents." We believe that the two volumes, though generally regarded as one series, were published separately, with distinct titles. 5th, *Histoire Naturelle des Promerops, et des Guépiers*, 1 vol. folio, 1807. This rare and beautiful volume

History. sometimes occurs alone, sometimes as forming volume third of the preceding series. A complete collection of Le Vaillant's works forms of itself a noble *gallery* of ornithological portraits. The letter-press, more especially that of the *Oiseaux d'Afrique*, is also of great value, and will be studied with additional advantage by those familiar with the delightful narrative of his first and second Travels into the Interior of Africa, 1790–95.

As belonging to the same class of works, and also of excellent execution, may be mentioned Desmaret's *Histoire Naturelle des Tangaras, des Manakins, et des Todiers*, 1 vol. folio, 1805. M. Vieillot, who died in 1828, after a very active career in Ornithology, is the author of the following works, all of a sumptuous character, and of considerable value in their way, though inferior in beauty to those of the two preceding authors. *Histoire Naturelle des plus beaux Oiseaux Chanteurs de la Zone Torride*, 1 vol. folio, 1805;—*Histoire Naturelle des Oiseaux de l'Amérique Septentrionale*, 2 vols. folio, 1807;—*Galerie des Oiseaux*, 4 vols. 4to, 1826, an extensive series of figures, chiefly from the collection of the museum in the Garden of Plants. M. Vieillot is likewise the continuator of Audebert's *Histoire des Oiseaux dorés, ou à reflets métalliques* (2 vols. folio, commenced in 1802); and has written largely on systematic Ornithology in the *Encyclopédie Méthodique* (*Ornithologie*, by the Abbé Bonnaterre, continued by M. Vieillot, 3 vols. 4to, besides the plates, Paris, 1823); and in the *Nouveau Dictionnaire d'Histoire Naturelle*. Lastly, he indicated various new groups, or at least a variety of groups under new names, in his *Analyse d'une Nouvelle Ornithologie Elémentaire*, Paris, 1816; a work which seems to have occasioned great offence to M. Temminck,[1] and some dissatisfaction to Baron Cuvier.[2]

Alexander Wilson's admirable *American Ornithology, or Natural History of the Birds of the United States*, was published in nine volumes quarto (including Mr Ord's Supplement) between 1808–14. It still maintains its character as a work of the highest value, and although it has been since surpassed by other works in elegance of design and beauty of colouring, its descriptive or narrative portion has been scarcely equalled. Of this most remarkable production several editions have been published in America, and two in this country, viz. one by Professor Jameson, in a cheap and commodious form (four small volumes of Constable's *Miscellany*, No. 68—71, 1831), with the advantage of a systematic arrangement of the original materials,—another by Sir William Jardine (in three large 8vo volumes, 1832), with plates, and consequently of higher price, but enriched by numerous notes of great value.

We may here name the *General Zoology*, in fourteen volumes octavo, 1800–26, commenced by Dr Shaw, and concluded by Mr Stephens. The last seven volumes are devoted to Ornithology. Most of the plates are copies. Illiger's excellent *Prodromus Mammalium et Avium* was published at Berlin in one volume octavo, 1811. It establishes several new and important genera.

The first edition of the *Règne Animal* of Baron Cuvier (four vols. 8vo) appeared in 1817; the second (in five vols. 8vo) was published in 1829. We need say nothing of the surpassing excellence of a work which cast the whole subject of Zoology into a new and more natural form, nor of the unequalled labours of the illustrious author, by whom the structure and characters of so many important groups have been brought from darkness into light. The general features of his system have, with few exceptions, been steadily adhered to throughout the zoological treatises of this Encyclopædia, and (which is more to be admired) do History. equally pervade and illumine the labours of many modern authors who yet place themselves in opposition to his doctrines, and seem to have forgotten, or been blinded by, the dazzling source from which they drew their "golden light;" as if the false though gorgeous glory of a cloud could of itself adorn the beauty of the azure heavens,—as if the reflection of a sparkling river were any thing more than the borrowed lustre of the "Great Apollo." Let the reader rest assured, that however praise-worthy may be the skill and devotedness of our ingenious system-makers, or however valuable may be the materials which they have brought to bear upon isolated portions of nature's most majestic kingdom, they are yet separated, by the will of God, in head and hand, "longissimo intervallo," from their great master. This is no reason, but the reverse, for their ceasing to exercise their useful talents and natural powers of observation with assiduity and patience, as becomes alike the aspiring philosopher and the humble Christian;—but let no man mistake "the spirit he is of," nor suppose an owl an eagle, seeing that not in every acceptation of the phrase is it true, that "a living dog is better than a dead lion."

The natural history of the birds of Germany has been amply and successfully illustrated by the well-known works of Naumann (father and son), by those of Bechstein, and of Messrs Meyer and Wolf. We owe to M. Leisler a Supplement to the work of Bechstein (Hanau, 1812–13), and of Naumann's *Naturgeschichte der Vögel Deutschlands*, a second edition (in octavo), with beautifully-coloured plates, was commenced in 1820, and continued by his son till 1846. Meyer and Wolf's *Taschenbuch der Deutschen Vogelkunde* amounts to a number of volumes, and is filled with excellent observations; while their large illustrated work on German birds, commenced so far back as 1804, and now brought to a conclusion, is one of the most beautiful with which we are acquainted. M. Brehm published his *Beitrage zur Deutschen Vogelkunde* in 1820–22, in three large volumes, filled with minute details, which exhibit an accurate practical knowledge of the science. The author's views of species are peculiar. His *Lehrbuch der Naturgeschichte aller Europäischen Vögel* (two volumes) was published in the following year. In this, too, he surely describes local races, or accidental varieties, as distinct species. To M. Brehm we likewise owe several fasciculi of a work commenced in 1824, and published at intervals, under the title of *Ornis*. It consists of memoirs and memoranda, by various authors, relating chiefly to Ornithology. Lastly, we may here name his *Handbuch der Naturgeschichte aller Vogel Deutschlands* (Ilmenau, 1831), forming a goodly volume of 1100 pages octavo (with plates), which, M. Temminck remarks, may be reduced to at least one half, by suppressing the numerous indications of what the author calls *subspecies*. His system is partitioned into twenty-three orders, variously subdivided, and containing 196 genera.

Some important additions have been made of late years to the Ornithology of northern countries. The birds of Sweden are described by Professor Nilson of Lund, in his *Ornithologia Suecica*, Copenhagen, 1817–21. The same author published a *Skandinavische Fauna* in 1824; and a much more sumptuous work appeared at Lund in 1832, under the title of *Illuminerade figurer till Skandinaviens Fauna, mit text*. The first volume contains, besides quadrupeds, seventy-five figures of birds. In 1822 M. Boié gave forth his *Tagebuch gehalten auf einer Reise durch Norwegen*, in which, along with the narrative of his travels, he furnishes many valuable observations on the

[1] See his *Observations sur la Classification Méthodique des Oiseaux*, &c., 1817; and *Manuel d'Ornithologie*, Introduction to the second edition, p. x.

[2] *Règne Animal*, second edition, tom. i., note to Preface, p. 23.

History. history and manners of the birds of Norway. The same author published a work under the title of *Ornithologische Beitrage*, in 1824. M. Faber's excellent little volume, the *Prodromus der Islandischen Ornithologie*, appeared in 1822. It contains most interesting accounts of the birds of Iceland, especially the aquatic kinds; and not less valuable is his later publication, *Über das Leben der hochnordischen Vogel*, 1825, in which we have many acceptable observations on the geographical distribution, and the modes of life, of northern species. While on the subject of northern birds, we need scarcely recall to the reader's remembrance the various appendices to the *Voyages* of Parry and Franklin; likewise Sabine's *Memoir on the Birds of Greenland* (Linn. Trans. vol. xii.); or the beautiful work by Dr Richardson and Mr Swainson on the birds of Northern America, which constitutes the second volume of the *Fauna Boreali-Americana*, 1831.

We have few systematic works devoted to the Ornithology of the more southern countries of the European continent. We are ourselves acquainted only by name with the *Ornitologia dell' Europa Meridionale* (dedicatio signata 1772), in fol. max., by Clement Bernini, a teacher of drawing. The birds of France in general are described by M. Vieillot in the corresponding portion of the *Faune Française*, an octavo work, still in course of publication; and those of Provence in particular, by M. Polydore Roux in his *Ornithologie Provençale*, 1825. Of a more general character, though not without its bearings on our present subject, is the *Histoire Naturelle de l' Europe Meridionale* by M. Risso of Nice, in five volumes 8vo, 1826. We have already had occasion to name the *Storia Naturale degli Uccelli*, published at Florence in 1767; and Cetti's more restricted one, *Gli Uccelli di Sardigna*, 1776. In more recent times (1811), Professor Bonelli of Turin published a *Catalogue des Oiseaux du Piémont*, containing two hundred and sixty-two species. In 1822, Giambatista Baseggio inserted in the twenty-eighth volume of the *Biblioteca Italiana* an enumeration of the birds observed by him in the neighbourhood of Bassano, amounting to a hundred and thirty-seven species. In 1823, Fortunato Luigi Naccari printed at Treviso his *Ornitologia Veneta, ossia Catalogo degli Uccelli della provincia di Venezia*, in which he notices two hundred and six species. In the same year Savi the younger published, at Pisa, his *Catalogo degli Uccelli della Provincia Pisana, e loro Toscana Sinonimia*. The species are classed in accordance with M. Temminck's system, and amount to two hundred and twenty. From 1819 to 1826, Professor Ranzani of Bologna gave forth his excellent *Elementi di Zoologia*, of which the third volume, consisting of nine parts, is devoted to the natural history of birds. It is, however, a general system, treating of exotic as well as of indigenous kinds; yet a good deal may be gleaned from it regarding the Italian species. A work of more special interest is the *Specchio comparativo delle Ornithologie di Roma e di Filadelfia*, by Carlo Bonaparte, commonly called the Prince of Musignano. In this slight but highly interesting volume (republished in the *Nuovo Giornale de' Letterati* of Pisa), the author compares the Ornithology of two distant regions of Europe and America, lying, however, under nearly the same latitude, and records his observations on their history and manners. Of the species of the Roman territory we had previously scarcely any knowledge, and the Prince makes us acquainted with not fewer than two hundred and forty-seven. By the same author we have also *Osservazioni sulla Seconda Edizione del Regno Animale del Baron Cuvier*, inserted in the tenth and eleventh fasciculi of the *Annali di Storia Naturale* of Bologna; and he afterwards commenced the *Iconografia della Fauna Italica*,—a sumptuous lithographic work, in large quarto, devoted to Italian zoology,—consisting of thirty numbers, forming three handsome vols. royal quarto, with magnificently-coloured plates, published at Rome, 1834–1842. Though not relating to Italy, we may here mention our author's other works, viz. *American Ornithology, or the Natural History of Birds inhabiting the United States, not given by Wilson*, with coloured figures, three volumes quarto, Philadelphia, 1825–28 (only the land-birds have yet been published);—*Observations on the Nomenclature of Wilson's Ornithology*, Philadelphia, 1828;—and *Generâ of North American Birds, with a Synopsis of the species found within the territory of the United States*, New York, 1828 (published in the *Annals of the Lyceum* of that city). The birds of Liguria are enumerated and briefly described, particularly the immature conditions of the plumage, by Girolamo Calvi in his *Catalogo d' Ornitologia di Genova*, 1828. History.

One of the most important works with which we are acquainted on the birds of Italy, is the *Ornitologia Toscana* of Professor Savi, in three vols. 8vo, with additional synoptical tables, Pisa, 1827–31. Though more specially devoted to the birds of Tuscany, it also contains descriptions of all the other Italian species, and may be regarded as a most valuable addition to our knowledge of the feathered tribes of Europe. The southern position and delightful climate of the Italian Peninsula induce the wandering wings of many species elsewhere *raræ aves* to wend their way towards the olive groves and richly laden fig-trees of that favoured land,—thus connecting the Ornithology of Europe with that of Africa and other sultry regions.

We may be thought, in some of our preceding notices, to have entered too minutely into the enumeration of descriptive local works, but we have been guided in so doing by two considerations: *1st*, That none of our English writers ever make any allusion to Italian Ornithology, except by casual reference to Carlo Bonaparte; and, *2dly*, that Buffon has recorded as his opinion, that "le seul moyen d'avancer l'ornithologie historique, seroit de faire l'histoire particulière des oiseaux de chaque pays; d'abord de ceux d'une seule province, ensuite de ceux d'une province voisine, puis de ceux d'une autre plus eloignée; reunir après cela ces histoires particulières pour composer celle de tous les oiseaux d'une même climat; faire la même chose dans tous les pays et dans tous les différens climats; comparer ensuite ces histoires particulières, les combiner pour en tirer les faits, et former un corps entier de toutes ces parties separées."[1]

The *Natural History of British Birds*, by Donovan, in ten volumes octavo, is a work of no great merit. Its period of publication extends from 1799 to 1816.

To no one of our recent writers is Ornithology more deeply indebted than to M. Temminck. His *Histoire Naturelle Générale des Pigeons et des Gallinacées*, three volumes octavo, appeared in 1813–15. The portion which concerns the pigeons was also published in folio, with beautiful coloured plates, by Madame Knipp. His *Manuel d' Ornithologie, ou Tableau Systématique des Oiseaux qui se trouvent en Europe*, 1815, consisted at first of a single octavo volume; but a greatly improved and extended edition in two volumes appeared in 1820. Whatever difference of opinion may prevail in regard to the author's system, naturalists are agreed that this is by far the most valuable work we yet possess on the birds of Europe. Its main excellence consists in the attention bestowed upon the sexual distinctions, and the successive changes of plumage from youth to age. The first volume contains, under the title of *Ana-*

[1] *Histoire Nat. des Oiseaux*, Plan de l'Ouvrage.

History. *lyse du Système Générale d'Ornithologie*, a classification of birds in general. Instead of a third edition of his *Manuel*, the author published in 1835 a third *part*, as a supplement to the first volume, and a few years afterwards he gave out a fourth *part*, or supplement to the second volume. These parts contain the corrections and additions rendered necessary by the lapse of many years. But M. Temminck has not confined his attention to the birds of Europe. In 1820 he commenced (in conjunction with M. Meiffren de Laugier) his *Planches Coloriées*, a work intended as a continuation and completion of the well-known *Planches Enluminées* of Buffon. It is printed in both a quarto and a folio form, and now amounts to one hundred and two parts, which concludes (so far, at least, as the first great series is concerned) what was originally designed by the author. It forms five volumes, composed in all of five hundred and ten plates, exhibiting seven hundred and fifty-five figures of birds, the majority unknown to prior writers. Each plate is accompanied by corresponding letter-press, containing the generic characters, the description of the species figured, and in many instances by general observations on the distribution and construction of groups. The two concluding numbers contain a general index, as well as the tables and titles of the volumes. Now that this work has been completed, we trust M. Temminck will be encouraged to proceed to another series, as we know his materials are abundant, if not inexhaustible. It would in truth be desirable that some such established work should be generally regarded as a proper medium for the publication of new or rare subjects in Ornithology, for it is the bane of natural history in general, that every year should be distinguished by the appearance of numerous abortive attempts, which each succeeding season condemns to oblivion. Thus the tax becomes both heavy and unproductive, yet we fear that national pride and personal vanity will long prevent the introduction of a better system. We do not mean to say that we possess not among ourselves individuals competent to do the subject justice, but assuredly there is much labour lost by a want of concentration.

In connection with the labours of the last-named author, we may here mention M. Werner's lithographic work, entitled *Atlas des Oiseaux d'Europe, pour servir de complément au Manuel d'Ornithologie de M. Temminck*, in two thick vols. 8vo, with 530 plates, 1848. M. Temminck had figured a few European novelties in his *Planches Coloriées*, but he appears to have remitted most of his rare indigenous kinds to M. Werner; and we are happy to find that he has communicated, so far as the publication of his European species is concerned, with our zealous and intelligent countryman Mr Gould. This leads us to record the title of one of the most sumptuous and beautifully executed works within the whole range of ornithological illustration, viz. *The Birds of Europe*, by John Gould, F.L.S. now completed in five volumes royal folio. The plates are chiefly from lithograph drawings by Mrs Gould, but many are also by Mr Lear, one of the best ornithological draftsmen the world has yet seen. Mr Gould's other works, all of recent date, and of the same form and character as the preceding, are as follow:—*a Century of Birds, from the Himalaya Mountains*;—*a Monograph of the Toucans*;—*a Monograph of the Trogons*;—and, *a Synopsis of the Birds of Australia*.[1] The latter is in a more portable form than the others; but it is the author's intention to illustrate the Ornithology of New Holland in the same mode as that in which he has treated the birds of Europe. History.

To M. Lesson the Ornithologist stands indebted for several publications, both of a sumptuous and useful character. The last edition of his work on humming-birds bears the following title: *Les Trochilidés, ou les colibris et les oiseaux mouches, suivi d'un index général, dans lequel sont décrites et classées méthodiquement toutes les races et espèces du genre Trochilus*, Paris, 1832, with seventy coloured plates. Conjointly with M. Garnot, he published some figures of birds in the Zoological Atlas to Duperrey's *Voyage autour du Monde*, as well as in his own *Centurie de Zoologie*. His other works specially devoted to our present subject are,—*Manuel d'Ornithologie*, two volumes 18mo, 1829; *Traité d'Ornithologie*, two volumes 8vo (with 119 plates), 1831; and *Histoire Naturelle des Oiseaux de Paradis, des Sérícules, et des Epimaques*, one volume 8vo (with 41 coloured plates), 1835.

Mr Swainson's beautiful *Zoological Illustrations* (First Series 3 vols. 8vo, 1820–23, Second Series 3 vols. 8vo, 1832–3) contain representations of many rare and remarkable birds, and yield to none with which we are acquainted, either in elegance or accuracy. By the same author (conjointly with Dr Richardson) we have, as already noted, the *Fauna Boreali-Americana*, Part Second; and (without other aid than his own delightful pencil) several fasciculi of the *Birds of Brazil*. More recently Mr Swainson has entered into a minute as well as extended exposition of the *Natural History and Classification of Birds*, in two volumes (1836–7), which form the ornithological portion of Dr Lardner's Cyclopædia. These will amply repay the most attentive study.

The birds of South America, which, like all the productions of that splendid country, are extremely gorgeous, have been here and there illustrated in various works, and are partially so by Mr Swainson in one of those just named. In Azara's *Voyages dans l'Amérique Méridionale* (1809, 3d and 4th volumes) there are descriptions of many hundred species from Paraguay and La Plata. The ornithological portion of the French edition was translated, with notes, by Sonnini.[2] A great mass of Brazilian species is described and figured in Spix's *Avium Species Novæ*, &c. 2 vols. 4to, 1824–26; while the habits of several of the more curious birds of Demerara are recorded in Mr Waterton's eccentric and well-known *Wanderings*.

The Ornithology of North America has been illustrated in an extremely full and satisfactory manner. Indeed, of the feathered tribes of no country out of Europe, equal in extent, do we possess so ample and accurate a knowledge as we do of those of the United States. We have already mentioned the immortal work of Alexander Wilson, and its excellent continuation by Charles Lucien Bonaparte; but at present we have to record the title of a much more magnificent publication than either, we mean *The Birds of America, engraved from Drawings made in*

[1] See list of recent works on Ornithology at the end of this article.

[2] The truly important works of Don Felix Azara seem better known to European readers by the French translations than the original Spanish publications. He devoted all his leisure hours, whilst in South America, to the pursuits of natural history, from the year 1782 to 1801. He then transmitted the manuscript of his *Apuntamientos para la Historia Natural de los Quadrupedos del Paraguay* to his brother Don Josef Nicolas, who handed it over to a French professor, M. Moreau de Saint Méry, by whom it was translated, and published under the now well-known title of *Essai sur l'Histoire Naturelle des Quadrupèdes du Paraguay*, 2 vols. 8vo, Paris, 1801. The original, however, appeared at Madrid in the following year, with corrections and additions by the author. In 1802 he likewise published his ornithological work under the title of *Apuntamientos para la Historia Natural de los Pajaros del Paraguay y Buenos Ayres*; and this portion of his labours forms the two concluding volumes of the French translation, entitled *Voyages dans l'Amérique Méridionale de* 1781 *jusqu'en* 1801, 4 vols. 8vo, Paris, 1809.

History. *the United States*, by John James Audubon, F. R. S., &c. 3 vols. folio, London, 1831–37; an undertaking which far exceeds in size and splendour all its predecessors in this, or indeed in any other department of Zoology. The dimensions of the work, as we have elsewhere noticed, are such as to enable the author not only to represent the largest birds of the United States, of the size and in the attitudes of living nature, but to figure a great proportion of them in family groups, so admirably conceived and skilfully executed, as really to form historical pictures of the highest interest to the general observer, and of the greatest utility to the student of Ornithology. The completion of each volume of plates is immediately followed by a large octavo volume of descriptive and general history of all the species therein contained. Mr Audubon far excels Wilson as an ornithological draftsman, and often equals him in his lively, eloquent, and interesting details of the life and manners of the feathered tribes. His descriptive volumes are entitled *Ornithological Biography, or an Account of the Habits of the Birds of the United States.* They amount to five in number; and were published at Edinburgh between the years 1831 and 1839. The entire work is characterized by unusual excellence both in science and art.

An extremely useful and well-concocted work, of less ambitious form than the preceding, is the *Manual of the Ornithology of the United States and of Canada*, by Thomas Nuttall, F. L. S., in two compact octavo volumes, Cambridge and Boston, 1832–34. The author made a scientific tour, some years ago, through the great western territories, including an extended range of the Rocky Mountains, with the design of extending his acquaintance with natural science.

Although we have hitherto confined our bibliographical notices chiefly to the works of foreign writers, we have done so not in consequence altogether of our own poverty, but rather for the more ample information of the English reader, who may be supposed to require less assistance in regard to British authors. We have scarcely even named the *British Birds* of the unequalled Bewick. We name it, and nothing more, believing that every one who delights to see nature in art, is familiarly acquainted with a work which may be keenly relished without any arduous study, but which those who study most will best appreciate and enjoy. Although the descriptive portion is written with accuracy and intelligence, we doubt not it would be advantageous to the author's family, and prove a labour of love to one or more of the many skilful Ornithologists of the present day, that the plates should be re-arranged in conformity with modern views, the supplement incorporated, the synonyms increased, and such rational alterations or additions effected, as would render it the manual of British Ornithology, if not for all time coming, yet for many future years. If accompanied by portions of the author's autobiography, so much the better. We regret that the latter, so racy and original, should have not yet seen the light. The most recent and complete edition of Bewick's Birds is that of 1832. A very beautiful preface is prefixed to the one published in 1826.

The most original *descriptive* works on the birds of Britain are Montagu's *Ornithological Dictionary*, 2 vols. 8vo, 1802, and *Supplement* to the same, 1 vol. 8vo, 1813. These were not only excellent works on *British* birds simply as such, but valuable additions to the actual history of European species,—the chief merit of many of our other publications consisting in their applying the knowledge acquired by foreign writers to our indigenous kinds; whereas Montagu rather gave than borrowed, his observations being almost entirely original. His volumes are now extremely rare in their first form; but a new edition, combining both works in one, was brought out in 1831, with notes, by Mr Rennie.

Dr Fleming, in his *History of British Animals*, one vol. octavo, 1828, enumerates and describes the birds of Britain. Of this work, which has been very useful to some who say rather too little about it, we should desire to see a new edition, remodelled in accordance with the alterations and additions rendered necessary by the lapse of years. It is a publication of great merit. History.

The letter-press to Mr Selby's folio *Illustrations of British Ornithology* (we mean the second edition, in two vols. 8vo, 1833) forms the best completed work we yet possess in accordance with the modern method of arrangement. Jointly with Sir William Jardine, Mr Selby has also brought out many fasciculi of *Illustrations of Ornithology* (small folio), in which are figured various interesting and curious forms of foreign species; and his well-instructed coadjutor was editor (and of several volumes author) of the *Naturalist's Library*, in which a due portion is successfully devoted to the history and representation of the feathered tribes. Both publications have done much to extend the knowledge of natural history.

One of the most valuable and carefully constructed works with which we are acquainted is the *Systema Avium* of Dr Wagler, pars prima, Stuttgard, 1827. It consists of a series of monographs, not in systematic order, but including several extensive and difficult genera, such as *Picus*, *Columba*, &c. The author unfortunately died not long ago, in consequence of a gun-shot wound accidentally inflicted by himself while sporting, and the non-completion of his work may be regarded as a great loss to Ornithologists. Various additional though detached portions of it, however, may be found in the *Isis*, a German periodical published at Frankfort. Wagler is also the author of a valuable descriptive summary of the parrot tribe, under the title of *Monographia Psittacorum*, one vol. 4to, Munchen, 1835. Our best previous treatise on that gorgeous family was published by the lamented Kuhl, in the *Nova Acta* of Bonn, vol. x. Of illustrated works on the subject, we have already mentioned that of Vaillant; and the English reader need scarcely be reminded of the extreme beauty of Mr Lear's more recent *Illustrations of the Psittacidæ*, in one vol. royal folio.

A considerable flock of ornithological authors has recently appeared above the horizon, to enlighten, however, rather than obscure our vision. We shall name a few.

Outlines of the Smaller British Birds, by R. A. Slaney, Esq. 12mo, 1833.

Familiar History of Birds, by the Rev. Edward Stanley, 2 vols. 12mo, 1835.

Manual of British Vertebrate Animals, by the Rev. Leonard Jenyns, 1 vol. 8vo, 1835.

Feathered Tribes of the British Islands, by Robert Mudie, 2 vols. 8vo, 1836.

History of the rarer British Birds, intended as a supplement to Bewick, by T. C. Eyton, Esq. 1836.

Of these, and other contemporary writers, the reader will find more ample notice in Mr Neville Wood's *Ornithologist's Text-Book* of 1836.

The following works relate particularly to the more musical of the feathered tribes: *Harmonia Ruralis, or Natural History of British Song Birds*, by James Bolton, folio, 1794;—*British Warblers*, by Robert Sweet, F. L. S. 8vo, 1823–32;—*Treatise on British Song Birds*, by Patrick Syme, Esq. 8vo, 1823;—*British Songsters*, by Neville Wood, Esq. 8vo, 1837;—*Cage Birds, their Natural History, Management*, &c. (translated from the German), by J. M. Bechstein, 12mo, 1837.

The late Mr Yarrell commenced his excellent *History of British Birds* in 1837, illustrated by a woodcut of each species, and numerous vignettes. The illustrations are for the most part remarkably accurate as ornithological representations, and of extreme beauty in a pictorial point of view.

Structure. The thirty-seventh part, completing the work, and forming three handsome volumes, was published in 1843. In the second edition of 1845, the author, besides other additions, published a supplement containing an account of the species obtained since the publication of the first edition.

Last in our list, though the reverse of lowest in our estimation, stand Dr Macgillivray's characteristic volumes the *Rapacious Birds of Great Britain* (1836), and the *History of British Birds, Indigenous and Migratory* (vol. 1st, 1837). In regard to these two works, readers may probably differ in their appreciation of some insulated passages, critical or otherwise, not essential to the exposition of the subject in hand; but we think all must agree that they are written in a clear, vigorous, and original manner, and devoid of that vapid spirit of compilation which pervades the labours of so many of the ingenious author's predecessors and contemporaries.[1]

We shall not here enter into any detailed exposition of the internal structure of birds. Our space would not admit of our doing so in a manner likely either to satisfy ourselves or to instruct our readers. The subject is of too great importance to be superficially treated, and a deeper scientific examination is not to be looked for here. We regret to say, there is much reason to accuse the naturalist of confining his attention to the external characters of living beings, which, though important portions of the animal economy, are nevertheless only portions, though too often looked upon as all in all. It is no reason for neglecting the internal structure, that a knowledge of such structure is not required to comprehend the modern systems. This, we must admit, is true; but the systems are thereby so much the more defective. An assured anatomical basis will never cause confusion or contrariety in any *good* arrangement formed on the groundwork of external characters; for the best of these are sure to conform themselves with all the important modifications of internal structure, while the sooner a bad arrangement is undermined the better. At the same time, that Zootomist would know little of the practical importance of external forms who should not endeavour to connect these with his demonstration of more recondite characters. In truth, however desirable it may be to know the whole of the animal structure, whether external or internal, we must in relation to museum specimens and to zoological collections in general, necessarily have recourse to superficial, or at least external characters, because none other are visible, or indeed exist, in the subjects of natural history as usually preserved; and we should debar a vast multitude from a most delightful study of graceful forms and gorgeous plumage, if we could learn nothing important of beast or bird without prying into all the hidden wonders of its interior. Whatever progress comparative anatomy may in future make, we trust the Zootomist will ever bear in mind that the establishment of good external characters is a matter of the highest and most indispensable importance to the present state and future progress of natural history, of which the practical pursuit will ever mainly depend upon the class of characters in question. As we cannot here enter into the anatomical department of our subject, we shall give, in the subjoined note, the names of a few works likely to interest and instruct the reader.[2] A few paragraphs will suffice for all we have ourselves to say, before entering upon our systematic portion.

The bill, composed of the upper and under mandible, varies almost infinitely in its form in the different genera, in the determination and construction of which it affords characters of the highest importance. As its modifications will be specially alluded to in our notices of the minor groups, and are moreover accurately represented in the plates which accompany the present treatise, we need not here fatigue the reader by an unnecessary enumeration. A portion at the base of the upper mandible, usually containing the nostrils, and sometimes covered with hairs or feathers, sometimes partially or entirely bare, is called the *cere*. It is very obvious in most birds of prey, but imperceptible in many other species. When we expand the mandibles, we of course perceive the opening to the alimentary canal or digestive organs, which usually consist of the following portions. Structure.

The *pharynx* follows immediately after the cavity of the mouth. It leads into the *œsophagus* or gullet, which in many species swells into what is called the *crop*, by some regarded as the first stomach. This is followed by a second enlargement, produced, however, rather by a thickening of the coats than by any increase of capacity within, named the *proventriculus*. It contains numerous glandular sacs interposed between its muscular and mucous coats, which secrete a gastric juice to aid the process of digestion. This proventriculus leads to the *gizzard* or true stomach, by some regarded as the third stomachic expansion. Here the function of digestion is completed. The entrance from the stomach to the small intestine is named the *pylorus*, of which the structure is frequently valvular. The first fold of the small intestine is named the *duodenum*, and after receiving the pancreatic and biliary ducts, it forms various convolutions, and terminates in the rectum or large intestine. The *cæca* are usually placed at the commencement of the latter; its termination is named the *cloaca*.

These parts, it will be borne in mind, are variously modified in the different tribes. In some the expansion called the crop is wanting, or not to be distinguished from the other upper portions of the œsophagus; and the powerful muscles which constitute the peculiar strength of the gizzard in granivorous birds are very feeble in the carnivorous and fish-devouring kinds. In some the intestine is long and narrow, in others short and wide, while the cæca exhibit a corresponding range, being in certain kinds extremely long, in others merely rudimentary.

Birds are remarkable for the energy of their respiratory functions. Although their lungs are rather small, they are perforated in such a way as to communicate with membranous cells distributed through various parts of the body, and even communicating with the interior of the bones, so that the atmospheric air not only comes in contact with the pulmonary vessels, but with a great proportion of the circulating system. Thus birds have been said to respire by the branches of the aorta, as well as by those of the pulmonary artery. It is thus that the most rapid exercise of the faculty of flight impairs not their power of breathing; and the best-trained hunter that ever bounded rejoicingly over the fences of Leicestershire is far sooner blown than a field sparrow.

The *trachea* or wind-pipe is composed of bony rings. The *upper larynx* is of comparatively simple structure, and of less importance than among the mammiferous class; but farther down, and close upon the bifurcation of the trachea, is the *lower larynx*, the true organ of the voice in birds. The vast bulk of air contained in the interior cells no doubt contributes to the strength of their vocal powers, while the muscles of the inferior portion of the larynx, and

[1] For the more recent publications on Ornithology, see the end of the present article.

[2] Cuvier's *Leçons d'Anatomie Comparée;* Carus's *Introduction to Comparative Anatomy*, translated from the German by Mr Gore (there is a better and more recent French edition of this work); Meckel's *Traité Général d'Anatomie Comparée;* Grant's *Outlines of Comparative Anatomy;* Mr Owen's article AVES, in Todd's *Cyclopædia of Anatomy and Physiology;* and the *Introduction* to Macgillivray's *History of British Birds*, vol. i.

Structure. the length, diversified form, and varied movements of that organ, bestow upon it a great facility of modulation.

The anterior limbs of birds, corresponding to the fore legs of quadrupeds, have been converted into wings for the purposes of that aërial locomotion commonly called flight. It is true that some birds cannot fly, that is, leave not the surface of the earth; but these are exceptions to the general rule, and even among such exceptions the great majority use their wings as a propelling power, whether coursing amid dry and barren deserts, or submerged beneath the waves. The bony portions of the wings consist of the *humerus*, the *cubitus*, the *carpal* and *metacarpal* bones, and *fingers*. We shall briefly describe these parts in so far as they are connected with the imposition of the plumage, and consequently with the external characters of the feathered race. The reader, if he so inclines, may here consult Plate III., figures 3 and 4. The *humerus* or arm bone (*c*) is joined to the body by means of a part of its own upper surface, which articulates with a corresponding cavity between the coracoid bone (*b*) and the scapula or shoulder-blade (*a*). It is directed backwards in repose, and in a position more or less parallel with the spine. The other extremity of the humerus articulates with the *cubitus* or fore-arm, which is composed of the bones called the *ulna* (*d*) and *radius* (*e*), and is so jointed as to fold when at rest in a direction parallel to that of the arm. The *carpus* consists of two small bones (*ff*) placed between the outer extremity of the cubitus and the *metacarpus*. The latter (*g*) usually consists of two bones united at both ends. From the anterior edge of the portion next the carpus, there projects a small bone, considered as analogous to the first digit or thumb, *pollex* (*h*); to the extremity of the outer portion of the metacarpus are usually attached two other digital bones (*i j*); and to the extremity of its inner portion is frequently appended a smaller bone of corresponding nature. These are the *fingers* of birds.

Now, the connection of the *plumage* with the preceding parts is as follows. Here consult Plate III., figures 1, 2, and 5. The small elongated tuft of stiffish feathers which clothe the upper exterior margin of a bird's wing, increasing in size downwards, pointing towards the base of the outer primaries, and commonly called the *alula*, or spurious wing (see S. W. in figs. 1, 2, and 5), springs from the portion we have called the thumb. The *primaries* or greater quill-feathers of the wings, that is, the *ten* outermost feathers, and which constitute the more or less pointed terminal portion (see figs. 1, 1 to 10, and figs. 2 and 5, at P. P.), spring from the digital and metacarpal bones. The *secondaries*, or lesser quill-feathers (figs. 1, 1 to 6, and figs. 2 and 5, at S. S.), which, when the wing is closed, usually cover a portion of the primaries, take their origin from the cubitus or fore-arm; while a third series, inconspicuous in most birds, though very obvious in others, and named the *tertials* or tertiary feathers (fig. 2, T. T.), are derived from the humerus or arm bone. Above these, and lying over that portion of the wing which joins the body (or, as it were, between the wing and back), are the *scapulars* (fig. 2, Sc.), usually of an elongated form, and often distinguished from the surrounding plumage by a difference of tint or marking. Lastly, various ranges of feathers which clothe the upper portion of the wings from the carpal joint backwards, covering the base of the primary and secondary quills, and spreading across from the spurious wing to the scapulars, are named the *wing coverts*, and are distinguished, according to their position, as the smaller coverts (figs. 1 and 2, at Sm. C.), which clothe the upper portion of the wing; the secondary coverts (figs 1 and 2, at S. C.), which protect the base of the secondaries; and the primary coverts, Structure. (figs. 1 and 2, at P. C.), which perform that office to the primaries. The feathers which clothe the under surface of the wings are named the *under coverts* of those parts; and the terms *upper* and *under tail-coverts* signify the feathers which cover the base of the tail, above or below. But we need scarcely occupy our pages with the numerous particulars which might be brought forward, and which occupy so prominent a space in many ornithological volumes. The terms in most cases explain themselves. When we speak of the crest of a bird, we of course mean to indicate the feathers on its head; and the upper, central, or lower portions of the back, can be respectively nothing more nor less than one or other of these portions. When we mention the point of the bill, we literally mean the point, and there is no word in the English nor in any other language which can express it more clearly. Neither do we think it necessary, in an English work, to give a corresponding Latin phrase for every term we use, more especially as many of these terms cannot be correctly Latinized, and in fact have never occurred at all in any books in that language. Their confinement, therefore, in a circumflexual prison, amid the unembarrassed freedom of the English tongue, is a sad and cruel mockery "of things attempted yet in prose or rhyme;" and we believe is but seldom practised by those who got through Ruddiman respectably in early life. We therefore deem it worse than useless to present an endless catalogue of *terms in Ornithology*, followed by explanations more obscure and ambiguous than the technicalities themselves; but shall rather endeavour either altogether to avoid unknown tongues, or, by the context, to render our meaning obvious to each capacity.[1]

Those minute discriminations, so often insisted on, are in truth but seldom necessary in the description of a bird's external aspect, especially of its feathered portions, because large spaces of the plumage have frequently an identical character both in texture and colour. Thus, if the entire head is either black, white, brown, or any other single colour, it would be a waste of words to describe it in any other way than simply as being of that colour; that is, it would be unnecessary to say that the frontal, vertical, occipital, auricular, and ocular feathers of the head were coloured after such a fashion; but if one colour prevails over another, and yet is traversed, or in any way varied by other colours, the precise region, whether frontal or occipital, in which the variation happens should be stated. We would almost say, that our nomenclature of the parts themselves depends to some extent on the distribution of the colours. Thus, of birds with a black abdomen and a scarlet breast, we can easily conceive, that even of the same species two individuals may so considerably differ in the proportional extent of the supposed colours, that the black in one instance shall encroach upon what corresponds to the scarlet of the other, or *vice versa*; but still the phrases "abdomen black, breast scarlet," would suffice for both, though not proportionally the same in each. The fact is, that many of the special regions of a bird are by no means precisely marked, or at least are seldom seen to be so, unless we strip it of its plumage,—an untoward act, however, for one who desires to stuff or otherwise preserve its skin; and therefore some latitude must be allowed in our expression of the external parts.

The next portion to be briefly described is the leg or hinder limb. This is divisible into the *femur*, *tibia*, *tarsus*, and *toes*. (See Plate III., fig. 3.)

The *femur*, or thigh-bone (*k*), is cylindrical, somewhat

[1] A very ample and interesting account of the diversified form of bills, feet, and feathers, will be found in Mr Swainson's *Natural History and Classification of Birds*, vol. i., illustrated by numerous wood-cuts from the elegant pencil of the author.

Structure

curved, usually very short, and always so concealed within the body as not to be apparent as an external portion of the limb. The next division is the leg or *tibia* (*m*), frequently but erroneously called the thigh, probably from its being the uppermost apparent portion. It is usually covered with feathers, though sometimes bare on its lower portion. Then follows the *tarsus* (*n*), that long, slender, exposed portion, so conspicuous in almost all the species, varying considerably among accipitrine birds, rather short in web-footed water-fowl, and greatly lengthened in the majority of shore-birds or waders. Its upper knobby portion, where it articulates with the tibia, is the true heel, although generally in colloquial, and not seldom in descriptive language, termed the knee. The prominences of its lower extremity articulate with the *toes*. The latter parts usually amount to four; the hind toe, however, is wanting in many species, and the ostrich is generally supposed to have only two toes, although Dr Riley has demonstrated the existence in that bird also of a rudimentary inner toe. The hind toe is by some regarded as the first, the inner as the second, the middle as the third, and the outer as the fourth toe; and in this order there is a progressive increase in the number of the joints of which each is composed,—the first having two, the second three, the third four, and the fourth five bones. The surface of the tarsus, toes, and sometimes of the base of the tibia when that part is exposed, is covered either with plated or reticulated scales, of various forms in different species; and the tarsus is moreover often armed with one or more spurs,—which, however, belong to the cutaneous rather than the osseous system. A general notion of the latter, as it exists in the class of birds, may be acquired by an inspection of the skeleton of the golden eagle just referred to (Plate III., fig. 3). We shall here add nothing more upon the subject.

The position, and therefore to a certain extent the nature, of many modern genera, of which we are unable from want of space to give the characters, will be seen in the tabular views with which we terminate the present treatise. A considerable discordance still prevails in regard to the nature and amount of the generic groups in Ornithology,—some writers advocating a numerous subdivision, and consequent restriction, of characters; while others adhere, perhaps too tenaciously, to old associations, which naturally tend to the augmentation of species, in other words, to the extension rather than the increase of genera. The former plan is rendered necessary to a great extent by the vast additions which have been made to our knowledge of groups and of typical species within the present century, and might be deemed advisable among the larger genera even as a mere matter of convenience;—its abuse in the hands of unskilful or inexperienced persons being of course no legitimate argument against it. There is, however, a great deal that is arbitrary and unsettled in whatever principle may be supposed to guide the modern naturalist in the formation of his generic groups. The simplicity and ease of application which characterised the former artificial systems have been lost in their attempted demolition, while the reconstructions now arising (in spite of the abundant though not always acknowledged appropriation of some useful old materials) are not yet so complete and commodious as to afford the same accommodation to the benighted student. Order will no doubt some day spring from chaos, and even already, amid the darkness of the upheaving waters, are many sunny spots of terra firma towards which we fondly steer, "well pleased that now our sea should find a shore." Naturalists, however, need by no means quarrel with each other, as if there was a certain good to gain, or some great physical truth to be established. "All the great business of genera and species," says Locke, "amounts to no more but this, that men make abstract ideas, and, setting them in their minds with names annexed to them, do thereby enable themselves to consider things, and discourse of them, as it were in bundles, for the easier and readier improvement and communication of their knowledge, which would advance but slowly were their words and thoughts confined only to particulars." "The reason," he says again, "why I take so particular notice of this is, that we may not be mistaken about genera and species, and their essences, as if they were things regularly and constantly made by nature, and had a real existence in things,—when they appear upon a more wary survey to be nothing else but an artifice of the understanding, for the easier signifying such collections of ideas, as it should often have occasion to communicate by one general term, under which divers particulars, as far forth as they agreed to that abstract idea, might be comprehended."

Genera.

The following observations by Mr Vigors may be introduced with propriety in this place, as according closely with our own views on the subject of generic divisions. "But though nature nowhere exhibits an absolute division between her various groups, she yet displays sufficiently distinctive characters to enable us to arrange them into conterminous assemblages, and to retain each assemblage, at least in idea, separate from the rest. It is not, however, at the point of junction between it and its adjoining groups that I look for the distinctive character. There, as M. Temminck justly observes, it is not to be found. It is at that central point which is most remote from the ideal point of junction on each side, and where the characteristic peculiarities of the groups, gradually unfolding themselves, appear in their full development; it is at that spot, in short, where the typical character is most conspicuous, that I fix my exclusive attention. Upon these typical eminences I plant those banners of distinction, round which corresponding species may congregate as they more or less approach the types of each. In my pursuit of nature, I am accustomed to look upon the great series in which her productions insensibly pass into each other, with similar feelings to those with which I contemplate some of those beautiful pieces of natural scenery, where the grounds swell out in a diversified interchange of valley and elevation. Here, although I can detect no breach in that undulating outline over which the eye delights to glide without interruption, I can still give a separate existence in idea to every elevation before me, and assign it a separate name. It is upon the points of eminence in each that I fix my attention, and it is these points I compare together, regardless, in my divisions, of the lower grounds which imperceptibly meet at the base. Thus also it is that I fix upon the typical eminences that rise most conspicuously above that continued outline in which nature disposes her living groups. These afford me sufficient prominency of character for my ideal divisions; for ideal they must be, where nature shows none. And thus it is that I can conceive my groups to be at once separate and united; separate at their typical elevations, but united at their basal extremes.

"It is difficult to convey, in terms sufficiently explicit, an accurate definition of abstract notions like the present. We may see the subject clearly ourselves, but not be able to communicate it by words sufficiently intelligible, unless to those who may happen to view it in the same light as ourselves. I shall therefore take a familiar illustration, which comes home to the feelings of every man, and where it will be immediately apparent that strongly marked divisional groups may be kept apart from each other in our conceptions, although we can recognise no absolute boundary lines by which we can say they are separated.

"Let us take, for instance, that period of time which in-

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volves the annual revolution of the earth round the sun, and let us divide it into the usual departments which we call seasons. Every man can picture to his own mind the decided characters by which these divisions of the year are parted from each other; he can mark out by definite distinctions those striking periods where the year bursts forth into bud, where it opens into flower, where it ripens into fruit, and where it lapses into decay. He can ascertain the nature of the impressions which each season forces upon his own feelings, he can communicate such sensations to others, and he can embody those natural periods, of whose separate existence he feels conscious, into separate and well-characterised divisions, to which he can refer, without fear of being misunderstood, under the distinct appellations of spring or summer, of autumn or of winter. But can he at the same time point out the actual limits of these natural departments of the year? Can he fix, for instance, in that intervening interchange of season, where the rigour of winter silently and imperceptibly relaxes into the mildness of spring,—can he fix, I say, upon the exact period when the former terminates, and the latter begins? Can he assert at one moment that he is within the precincts of one season, and that, even while he speaks, he has passed into the confines of the other. He may, it is true, assign artificial limits to each department, and may calculate with mathematical precision the months, the days, the hours, of which it consists. He may even assign reasons for his arbitrary divisions, and prove their probable approximation to the regular interchange of nature. And this is precisely as far as the Zoologist can go. But this is all that is in his power. He never can feel or assert that the character of one season is lost at one particular moment, and gives place to the character of that which succeeds. Here, then, we have four decided divisions, perfectly distinct in themselves, yet to which we are unable to affix the limits. So it is with the groups of Zoology. They exhibit separate divisions, distinguished by separate characters, but running into each other without any assignable limits; and any man may draw his imaginary line across that 'border country,' that 'land debateable,' which stretches between the conterminous regions, according as it suits his fancy or his peculiar views, or as it may accord with the greater or less preponderance of those minor landmarks which serve as an inferior mode of demarcation in the absence of all natural boundaries."[1]

We shall now proceed with our proposed exposition of the various orders.

Order I.—RAPTORES, OR BIRDS OF PREY.[2]

Raptorial birds, under which term we include the tribes usually known by the general names of vultures, eagles, hawks, buzzards, kites, and owls, are distinguished by a strong, sharp-edged, acutely-pointed bill, more or less curved, but always hooked at the extremity of the upper mandible, which is covered at the base by the membrane called the cere. The nostrils are usually open. The legs, with few exceptions, are plumed as far as the top of the tarsus; the latter part itself is usually bare, but is entirely covered with feathers in most of the nocturnal kinds, and partially so in several of the diurnal. The toes are always four in number, very free in their movements, the outer sometimes versatile; and the whole, with rare exceptions, are furnished with strong, sharp, curved, prehensile claws.

All raptorial birds feed on animal substances,—the majority on living prey. Representing in their own class the ferine species among quadrupeds, they subdue their weaker brethren by force more frequently than guile; and if not more tyrannical than tigers, they at least exercise a more extended sway, for the fields, the woods, and waters, the barren mountains, and resounding shore, are all alike subjected to their fierce control. Their power of flight is remarkable for its surpassing strength and long endurance. They occur in some form or other under every clime, and their external aspect varies greatly, both in size and shape, from the ponderous eagle and condor of long extended wing, to the finch-falcon of Bengal, which is scarcely larger than a sparrow. But, generally speaking, raptorial birds are of considerable bulk, as might be anticipated from the necessity under which they lie of subduing an active and not always unresisting prey. Their forms, however, are often graceful, their actions energetic, their eyes bold and bright, and their plumage beautifully varied;—but they are more remarkable for chaste and subdued colouring, for sober shades of intermingled black and brown, than for those brilliant or gorgeous hues which characterise so many of the feathered tribes.

Raptores.

Their dispositions naturally fierce or unaccommodating, if not contentious, their ravening appetites, and dangerous weapons, induce them but seldom to associate with each other. We shall not here describe them, after the manner of many authors, as gloomy and mistrustful,—for what cause has an eagle, rejoicing in his strength, and winging his way from distant isles o'er waters glittering with redundant life, or hovering on the side of some majestic mountain, of which the purple heath is one wide storehouse of the best of game,—what cause has he for gloom? Or why should he mistrust, whose sail-broad vans might almost carry him across the vast Atlantic, or assuredly in a few brief hours transport him from his bold but barren eyrie, to richer pastures, reverberating with the varied voices of defenceless flocks? We believe there is nothing mournful or disconsolate in beings which pursue the unfettered exercise of natural instinct. Such fearful attributes are but reflections from the melancholy mind of man (whose morbid *reason* often casts a gloom across the brightest sun), but cloud not in reality the face of nature. Birds of prey, however, are not gregarious,—although, "where the carcass is, there will the eagles be gathered together." For eagles we presume to read vultures, the scavengers of the raptorial order, which in sultry regions are highly useful in clearing all decaying offal from the earth. With these exceptions, the others may be said to dwell in single pairs,—at times in solitude. They build their rude but sufficing nests amid precipitous rocks, on ancient ruins, and occasionally among forest trees, while a few take up their station on the ground. They seldom lay more than four eggs, and many only rear a pair of young. These are at first extremely helpless, and covered for a time with down. The females, in the generality of species, are considerably larger than the males. The plumage of the sexes often differs greatly, and in such cases the offspring for one or more seasons resembles the mother.

The voice in the raptorial order is almost always harsh and unmusical, sometimes more plaintive in the hooting kinds, complaining by night from ivy-mantled tower or ancient tree; and only one species, a hawk from Africa, has been ever said to sing. The uses to the human race of birds of prey are not remarkable. The scavengers above alluded to are beneficial in their way, but the same can scarcely be alleged of such as carry off our lambs or poultry; and we are not aware that either their flesh or feathers are of much avail. More might have been said of certain members of the order, had not the practice of

[1] *Zoological Journal*, No. ii. p. 196.

[2] Accipitres, Linn.; Rapaces, Temm.

Raptores. falconry, with other chivalrous uses, been about to pass away.

SECT. I.—DIURNAL BIRDS OF PREY.

Cere usually naked, or partly covered by setaceous feathers. Nostrils open. Eyes of medium size, lateral. Head rather small, and elongated; face not surrounded by a completed disk of projecting feathers, as in owls. Sternum strong and solid. Stomach membranous. Intestines not greatly extended. Cæca short. Toes naked.

Of this section Linnæus and the other naturalists formed only two genera, *Vultur* and *Falco*, which some regard as forming two large families, subdivided into numerous minor groups. There is, upon the whole, a well-marked character, or at least a strong physiognomical distinction, between the *Vulturidæ* and *Falconidæ*; but this is more easily seen than expressed, or, when expressed, is often erroneously so. Thus a strong alleged distinction is the nearly naked head of the former; but the lammer-geyer (*G. barbatus*) has that part as densely plumed as any eagle. However, the nails are generally blunt, and the feet comparatively feeble.

FAMILY I.—VULTURIDÆ.[1]

The birds of this family are of large size and gluttonous habits. They prefer animal substances in a state of decomposition to living prey, and are frequently gregarious. The bill is never notched, and the feet and claws are more feeble and less curved than among the Falconidæ. Though indolent, especially after meal time, they are distinguished by great powers of flight. Their bodies in repose assume a more or less horizontal position. Their flesh is disgusting as an article of food, but their down has been occasionally made use of for domestic purposes.

Genus Vultur, Cuv. Bill large and strong, compressed, straight at the base, convex and rounded at the point. Nostrils naked, rounded, obliquely pierced. Head and neck bare of ordinary feathers, but covered by a short down. A collar of long soft feathers at the base of the neck.

The true vultures, as now restricted, belong to the ancient world. Their flight, though slow, is powerful and long sustained. They frequently rise, by repeated gyrations, to a great height in the air, and descend in a similar manner. They assemble in troops, and feed for the most part on carcasses; yet the Dalmatian shepherds are said to dread their inroads among their sheep and lambs. They build among inaccessible rocks, and feed their young by emptying the unsavoury contents of their own crops. It does not appear that they can transfix or carry off their prey by means of their talons, as do hawks and eagles.

We have two species in Europe, the cinereous vulture (*V. cinereus*, Linn., Plate IV., figure 1), called *arrian* on the Pyrenees, and the *griffon* or fulvous vulture (*V. fulvus*, Linn.) Both birds occur in Spain and the Tyrol, but are scarcely ever seen in Switzerland, and are rare in Germany. The nidification of the cinereous vulture is still unknown. It probably never breeds in Europe, but rather in the mountainous countries of Asia, where it is known to occur abundantly. The fulvous vulture is more courageous than the preceding, and more inclined to seize on living prey. It is common in the neighbourhood of Gibraltar, abounds in Dalmatia during winter, and has been observed to breed in Sardinia on lofty trees. It lays two eggs, of a greenish white, with a rugose surface. It is widely spread over the continent of Africa. Several other species are found in the warmer regions of the old world. Raptores.

Genus Sarcoramphus, Dumeril.[2] Bill thick, straight from the base, but strongly curved at the extremity, the margin of the upper mandible having a somewhat sinuous or S-like outline. Nostrils longitudinal and oblong. Head and neck bare, wattled, surmounted by a fleshy crest.

This genus is confined to America, and consists of three species, the famous condor of the Andes (*S. condor*), the king-vulture (*S. papa*), and the Californian vulture (*S. californianus*). The condor inhabits the loftiest of the Andes, and in its aërial flights is supposed to attain to a station far above that of every other living creature. According to Humboldt, it soars to an elevation nearly six times greater than that at which clouds are usually suspended in the sky. At the vast height of almost six perpendicular miles, the condor is seen majestically sailing through the ethereal space, watchfully surveying the airy depth in quest of his accustomed prey. When impelled by hunger, he descends to the nearest plains which border on the Cordilleras; but his sojourn there is brief, as he seems instinctively to prefer the desolate and lofty mountains. The barometer amid such aërial haunts attains only to the height of sixteen inches. These rocky eyries (of which the plain is elevated about 15,000 feet above the level of the sea) are known vernacularly by the name of *condor nests*. There, perched in dreary solitude, on the crests of scattered peaks, at the very verge of the region of perpetual snow, these dark gigantic birds are seen silently reposing like melancholy spectres. Hardly an instance is known of their assaulting even an infant, though many credulous travellers have given accounts of their killing young persons of ten or twelve years of age.[3]

The history of the condor, like that of its Patagonian neighbours of the human race, has in fact been much obscured by exaggeration. An inspection of its feet and claws suffices to show that it is not gifted with great prehensile power, and could scarcely carry off the most ill-conditioned child, though not seldom accused of such evil practices. Condamine informs us that he has often seen condors hovering over flocks of sheep, some of which they "would have carried away, had they not been scared by the shepherds;" and this vague supposition is stated as a *fact* in their natural history! It is a bird of powerful wing, but of vulturine habits, feeding much on dead animal matter, but not unfrequently joining together in the attack of cattle, especially of such as are in any way enfeebled. Although the usual station of the condor is mountainous, it often descends, as we have said, to feed among the plains and valleys; and a female, now in the French museum, was found at sea, sitting on the dead body of a floating whale. It breeds amid the inaccessible peaks of the Andes, making no nest, but depositing its eggs upon the arid rock. It is a large bird, of from three to four feet in length, with an extent of wing very variously stated, but probably sometimes reaching from ten to twelve feet. The female is of a much browner hue, and wants the caruncles. She is less in size than the male, an unusual circumstance in this order, although we suspect that the greater bulk of that sex is a feature chiefly characteristic of the hawks and eagles.

"In riding along the plain," says Sir Francis Head, "I passed a dead horse, about which were forty or fifty condors; many of them were gorged and unable to fly; several were standing on the ground devouring the carcass;

[1] On the modern groups into which this family is divisible, the reader may consult a paper by Mr Vigors in the *Zoological Journal*, No. viii. p. 368.

[2] *Vultur*, Linn. Cuv.; *Cathartes*, Illiger, Temm.

[3] Nuttall's *Manual of Ornithology*, i. p. 36.

them; one of the largest of the birds was standing with one foot on the ground, and the other on the horse's body; display of muscular strength as he lifted the flesh, and tore off great pieces, sometimes shaking his head and pulling with his beak, and sometimes pushing with his leg. Got to Mendoza, and went to bed. Wakened by one of my party who arrived; he told me, that seeing the condors hovering in the air, and knowing that several of them would be gorged,[1] he had also ridden up to the dead horse, and that as one of these enormous birds flew about fifty yards off, and was unable to go any farther, he rode up to him; and then, jumping off his horse, seized him by the neck. The contest was extraordinary, and the rencontre unexpected. No two animals can well be imagined less likely to meet than a Cornish miner and a condor, and few could have calculated, a year ago, when the one was hovering high above the snowy pinnacles of the Cordillera, and the other many fathoms beneath the surface of the ground in Cornwall, that they would ever meet to wrestle and 'hug' upon the wide desert plain of Villa-Vicencia. My companion said he had never had such a battle in his life; that he put his knee upon the bird's breast, and tried with all his strength to twist his neck; but that the condor, objecting to this, struggled violently, and that also, as several others were flying over his head, he expected they would attack him. He said, that at last he succeeded in killing his antagonist, and with great pride he showed me the large feathers from his wings; but when the third horseman came in, he told us he had found the condor in the path, but not quite dead."[2]

The king-vulture (*S. papa*, Plate IV., figure 3) is a much more gaily adorned species, the fleshy portions of its head and neck being red, orange, and purple. The upper parts of the plumage are of a pale reddish-white or clay colour, the collar at the base of the neck is bluish-gray, the quill-feathers and tail black (the former with paler edgings), and the under parts of the body white. This beautiful bird is found in America, from the 30th degree of north latitude, to about the 32d in the southern hemisphere; that is, it occurs in Mexico, Paraguay, Guiana, Brazil, and Peru; but most abundantly beneath the torrid zone. According to Azara, it makes its nest in hollow trees, and lays two eggs. It is supposed to derive its name from its habit of driving off the common vultures of America, called turkey buzzards, from their prey. The female king-vulture is of somewhat smaller size than the male. The ruff, and all the upper parts of her plumage, are brownish black, and her bill is destitute of caruncles.

Genus Cathartes, Illiger. Bill much more slender than in the preceding genera; the upper mandible inflated above the nostrils, encroaching as it were upon the forehead, curved at the point, the margins nearly straight; the under mandible slender, slightly inflated, and obtuse at the terminal portion. Cere extended. Nostrils broad, quadrangular, longitudinal, very open. Head and neck naked, without caruncles. Tongue fleshy, fringed. Tarsi naked, rather feeble; claws short, curved, blunt. Tail-feathers twelve.

This genus, as now restricted, is likewise confined to America. It consists of two species, the common turkey buzzard (so called in the United States), *C. aura*, Plate IV., fig. 2, and the carrion-crow (of the same country), *C. atratus*. The former is abundant both in North and South America, and extends, in the central districts of the fur-countries, as far north as the 54th degree. It is partially migratory, even in the middle states, retiring southwards on the approach of winter. A few remain throughout the year in Maryland, Delaware, and New Jersey; but none are known to breed in any of the Atlantic States to the north of the one last named. In the interior, however, they reach a much higher latitude during their summer migrations, probably owing to the greater heat of that season in the inland districts. A few make their appearance on the banks of the Saskatchewan when the month of June is far advanced, and after all the other summer birds have arrived and settled in their leafy arbours. Though gregarious in more southern countries, where they fly and feed in flocks, towards their northern limits seldom more than a pair are seen together. They feed on carrion, which they discover at a great distance, it is now said, by the sense of sight alone. They sometimes eat with such gluttonous voracity as to be unable to rise from the ground. They have been accused of attacking pigs, beginning the assault by picking out their eyes. But Mr Waterton, during his residence in Demerara, could not ascertain that they destroyed even living reptiles. He killed lizards and frogs and placed them in their way, but they took no notice of them till they began to emit a putrid effluvia. He differs from Mr Audubon in his ideas regarding the relative superiority in these birds of the organs of sight and smell. The one thinks the *eyes* have it, the other the *nose*. The turkey buzzard hatches her eggs in some swampy solitude, on a truncated hollow tree or excavated stump or log, laying them on the rotten wood. This species roosts at night on trees, but more seldom than the other kind in flocks. In winter they sometimes pass the night in numbers on the roofs of houses in the suburbs of the southern cities, probably induced to do so by the warmth which emanates from the chimneys. On fine clear days, even in the winter season, they amuse themselves by soaring majestically into the air, rising rapidly in large gyrations; and ascending beyond the thinnest fleecy clouds, they almost disappear from mortal view. In South America they will sometimes accompany the condor in his loftiest flights, rising, all fetid though they be, above the region of the purest Alps; and thus exhibiting an emblem of the mind of man, so often sunk in Epicurus' sty, yet for a time so raised by god-like genius, as not seldom to perceive "far off the crystal battlements of heaven."

The other species of this genus is the black vulture, or carrion-crow of the United States, *C. atratus*. It is rather less than the preceding, measuring about twenty-six inches in length, the general colour of the plumage dull black, with a dark cream-coloured spot on the primaries. It is more impatient of cold, and prevails chiefly about the larger maritime cities of South Carolina, Georgia, and Florida. They seem, from Mr Douglas's account, to proceed further north on the western side of the Rocky Mountains. Although they rise at times to a considerable elevation, their flight is less easy and graceful than that of the turkey buzzard. They are much more familiar, and in Charleston and Savannah may be seen walking the streets as demurely as domestic fowl. They sometimes become individually known; and a veteran with only one leg was observed to visit the shambles, and claim the bounty of a gentle butcher, for upwards of twenty years.

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[1] "The manner in which the Guachos catch these birds is to kill a horse and skin him; and they say that although not a condor is to be seen, the smell instantly attracts them. When I was at one of the mines in Chili, I idly mentioned to a person that I should like to have a condor: some days afterwards a Guacho arrived at Santiago from this person with three large ones. They had all been caught in this manner, and had been hung over a horse; two had died of galloping, but the other was alive. I gave the Guacho a dollar, who immediately left me to consider what I could do with three such enormous birds."

[2] *Rough Notes across the Pampas.*

Raptores.

Genus Neophron, Sav. *Cathartes*, Illig. *Percnopterus*, Cuv. Bill long, slender, rounded, inflated at the curvature of the upper mandible, which is much hooked at the extremity. Nostrils median, oval, longitudinal, open. Cere covering two thirds of the bill. Face, cheeks, and throat naked, also a space extending down the middle of the neck. Tongue oblong, linear. Tail of fourteen feathers.

These birds are inhabitants of the ancient world. They are less powerful than the true vultures, and of smaller size, but are still more useful in their scavengerial functions, their love of putrid flesh, and of all impurities, being insatiable. The rachamach of Bruce, or gingi vulture of Sonnerat (*Neophron percnopterus*, Sav.), affords a characteristic example. (See Plate IV., figure 4.) It is equal in size to a raven, the throat and cheeks naked, the feathers of the head and back of the neck long, narrow, and pointed. The plumage of the male is white, except the quill-feathers, which are black; that of the female and young is brown. This species has been described under a great variety of names. It occurs in several parts of Europe, more especially in Spain, Italy, and the Island of Elba. It is likewise widely distributed over Africa, where it is known to the Hottentots by the name of hougoop. It was held in great respect by the ancient Egyptians, and is frequently represented on the monuments of that mysterious people. It is said to follow caravans through the desert, for the sake of devouring every dead or unclean thing. We may add, that it has occurred once or twice in England.

Genus Gypaetos, Storr. Bill strong, straight, curved at the point, and somewhat inflated at the curvature. Cere basal, covered by strong bristly feathers pointing forwards. Nostrils oblique, oval, concealed by bristles. Tongue thick, fleshy, bifid. Head feathered. A tuft of bristly or hair-like feathers beneath the bill. Tarsi short, thick, feathered. Tail-feathers twelve.

This genus contains only a single species, the celebrated lammer-geyer, or bearded vulture of the Alps (*G. barbatus*). (See Plate IV., figure 5.) It is one of the largest, or at least the longest-winged, of all the European birds of prey, haunting the highest mountains, and preying on lambs, goats, chamois, marmots, &c. Its strength and prowess are probably exaggerated, for although its powers of wing are undoubtedly great, its legs and talons are proportionally more feeble than those of eagles and falcons. It is said not unfrequently to secure its alpine prey by descending upon it suddenly with rushing wing, and driving it over a precipice, devouring the shattered limbs at leisure. It builds among inaccessible precipices, and lays two eggs. It is now one of the rarest of the birds of Europe, though formerly not uncommon among the mountains of Tyrol, Switzerland, and Germany. The peasant sportsmen of the last century often killed them, and one, Andreas Durner by name, is quoted by M. Michahelles as having shot sixty-five with his own hand. Though a bird of rare occurrence, the bearded vulture is very extensively distributed. In Europe it haunts the steeps of the Pyrenean Mountains, and the central Alps from Piedmont to Dalmatia; it is described by MM. Larey and Savigny as occurring in Egypt, and by Bruce as an inhabitant of Abyssinia; it has been received both from Northern Africa and the Cape of Good Hope, by M. Temminck; in Asia it is known to cast its cloud-like shadow over the vast steppes of the Siberian deserts; while not many years have elapsed since Professor Jameson received it from the snow-capped ranges of the Himalaya Mountains.

Raptores.

The bird described by Bruce under the title of *Abou Duck'n*, or Father Long-Beard, is certainly identical with the lammer-geyer, although we have been sometimes puzzled to reconcile the comparatively feeble feet of the beautiful series submitted to our examination by Professor Jameson, with the meat-bearing prowess of the Abyssinian instance. On the loftiest summit of the mountain of Lamallon, while the traveller's servants were refreshing themselves after the fatigues of a toilsome ascent, and enjoying the pleasures of a delightful climate and a good dinner of goat's flesh, a lammer-geyer suddenly made his appearance among them. A great shout, or rather cry of distress, attracted the attention of Bruce, who, while walking towards the bird, saw it deliberately put its foot into a pan containing a huge piece of meat prepared for boiling. Finding the temperature, however, somewhat higher than it was accustomed to among the pure gushing springs of that rocky and romantic region, it suddenly withdrew, but immediately afterwards settled upon two large pieces which lay upon a wooden platter, and transfixing them with its talons, carried them off. It then disappeared over the edge of a "steep Tarpeian rock," down which criminals were sometimes thrown, and whose mangled remains may be supposed to have first induced the bird to select the spot as a place of sojourn. The traveller, in expectation of another visit, immediately prepared his arms, and it was not long before the gigantic creature re-appeared.

> As when a vulture on Imaus bred,
> Whose snowy ridge the roving Tartar bounds,
> Dislodging from a region scarce of prey,
> To gorge the flesh of lambs or yeanling kids
> On hills where flocks are fed, flies towards the springs
> Of Ganges or Hydaspes, Indian streams;
> But on his way lights on the barren plains
> Of Sericana, where Chineses drive
> With sails and wind their cany waggons light:—

So landed with far-stretched fanning pinions our lammergeyer, within ten yards of his expected savoury mess, but also within an equal distance of Bruce's practised rifle, which instantly sent a ball through its ponderous body, and the magnificent bird sunk down upon the grass, with scarce a flutter of its outspread wings.

We may here close our brief notice of the first great family of the raptorial order, merely remarking farther, that the species last alluded to, though not so regarded by any of our systematic writers, appears to us to bear a great resemblance to the kites.

FAMILY II.—FALCONIDÆ.

This extensive family corresponds to the ancient unrestricted genus *Falco*, now greatly subdivided by modern naturalists, but not yet very satisfactorily arranged.[1] It contains a vast assemblage of eagles, hawks, buzzards, kites, &c., all characterized by a more or less curved bill, of which the upper mandible is strongly hooked; by obvious or open nostrils, pierced in an almost always naked cere; and by curved retractile pointed talons. The head is never bare of feathers, as in most of the preceding family, and the eye-brows are usually bony and projecting.

The geographical distribution of the Falconidæ, considered in their generality, is universal, one or more species being found in all known countries from Spitzbergen to

[1] The genus *Falco*, which in the days of Linnæus did not exceed thirty-two different kinds, amounts, in the last edition of Dr Latham's *Synopsis*, to 247. We have no doubt it now exceeds 300 species, even although many of Latham's names are reducible to the rank of synonyms.

Raptores. New Holland, and several particular kinds having a very wide range, not only longitudinally across the whole temperate and northern parts of Europe, Asia, Africa, and America, but latitudinally through almost every clime. Most of them are, to a certain extent, migratory in their habits, although their movements are by no means so regularly periodical as are those of more laborious wing. In fact, the birds of this family, surpassing all others both in the duration and rapidity of their flight, are scarcely amenable to those natural laws which, in so many instances, appear to regulate or restrict the location of other tribes; and hence we find, that if a mural precipice, an insulated crag, the mouldering wall of a ruined castle, or the tortuous branch of some ancient and umbrageous forest tree, has been successfully sought for in spring as a secure retreat for the purposes of nidification and the rearing of their young, the other seasons of the year are usually spent in a life of wandering rapine. When we consider the facts which have been recorded of the flight both of hawks and pigeons, the migratory movements of birds in general become much less a subject of wonder (excepting always the beautiful instinct by which they are directed), than they would at first appear. It is well known that a falcon belonging to Henry II. of France, which had been carried to Fontainebleau, made its escape, and was retaken *next day* in the island of Malta, where it was recognised by the rings on its legs. According to Colonel Montagu, it must have flown with a velocity equal to fifty-seven miles an hour, supposing it to have been on wing the whole time. "But as such birds never fly by night, and allowing the day to have been at the longest, or containing eighteen hours of light, this would make seventy-five miles an hour. It is probable, however, that it neither had so many hours of light in the twenty-four to perform the journey, nor that it was retaken the moment of its arrival; so that we may fairly conclude that much less time was occupied in performing that distant flight." Another falcon having been sent from the Canary Islands to the Duke of Lermos, then in Andalusia, was found in Teneriffe *sixteen hours* after it had taken its flight from Spain. In regard to this instance the calculation is more simple, and less likely to prove erroneous, because, supposing the bird to have followed anything like a direct course, its flight from the coast of Andalusia to its native island would lie throughout over the waters of the ocean, and must therefore have been *continuous*. Now the distance being not less than 752 miles, that space divided by sixteen, the number of hours employed would give an average of forty-seven miles an hour for the whole course. At this rate, if a falcon were to leave the rock of Gibraltar on a Monday morning, it might enjoy eight hours repose, and yet reach Edinburgh Castle in the course of Tuesday forenoon. Pigeons have been shot in the far-inland forests of America with their stomachs full of fresh rice, which, to have resisted the digestive process, must have been swallowed *not many hours* preceding, but could not have been obtained within *eight hundred miles* of the place where they were killed.[1] It thus appears probable, that the most extended migratory movement which any species is required to perform, may in the greater number of cases be accomplished in a couple of days,—more frequently in the course of a few hours.

The numerous species by which this great family is constituted, though rarely adorned by those brilliant colours which characterize so many of the gentler tribes, are perhaps of all the feathered race the most remarkable for beauty of form and elegance of proportion. Their eyes are usually large and lustrous; their limbs, even when light, very strong and muscular, and armed with formidable claws with which they *pounce* their prey. Their general aspect (especially that of the true falcons), when compared with other birds, is well expressed by the word *noble;* and a single glance suffices to show that a combination of fierceness, energy, and courage, must form their predominating character. Like most other animals, however, whether human or brute, they are by no means insensible to kindness; and their instinctive sagacity, when directed by the skill and perseverance of man, has for ages been rendered subservient to his amusement in the sports of the field. But the princely art of falconry, whether from the progress of agriculture, the consequent minuter subdivision of land, and the increase of inconvenient barriers by the fencing of enclosed grounds,—or the tastes of men of rank and fortune having followed in another direction, has now almost entirely fallen into disuse. The species most generally trained for the purpose in this country appears to have been the peregrine falcon, but many other kinds are used in eastern regions; and even ponderous eagles are sometimes made subservient to the human will. Few things indeed more strongly illustrate the subduing influence of reason over instinct, than that a coarse illiterate groom, by tossing up a shapeless lure, should thus entice a proud rejoicing falcon from his airy height, and render him so submissively obedient as to forsake his soaring flight, and all his bright survey of field and river, and close contentedly his yet unwearied wings, to perch for hours upon a brawny arm, his lustrous eye encapped in velvet hood, and limbs "by jessies bound." Raptores.

We must be very brief in our indications of the minor groups; and of several subgenera, as they are called, we can do nothing more than give the names. We do not here adopt the division of noble and ignoble birds of prey, which we deem a distinction without a difference, seeing that some of the long-winged hawks are difficult to train, while several of the short-winged kinds are made with ease submissive to the human race.

The genus Daptrius of Vieillot (*Caracara*, Cuv.) is formed by the *Falco aterrimus* of Temm. (*Pl. Col.* 37 and 342). The cheeks and front of the throat are bare of feathers. The cere is haired. The adult plumage of the species named is black, with a white band spotted with black at the base of the tail; the bare portion of the face is flesh-coloured, the cere and legs yellow, the bill lead-coloured. The total length is about fifteen inches. It occurs in Guiana and Brazil. Its habits are unknown.

The genus Ibycter of the same author (*Caracara*, Cuv.) has the cere smooth, and the upper part of the neck, as well as the cheeks, bare of feathers. The stomach is also bare and prominent. The tarsi are short, strong, and reticulated. We believe there is only a single species of this genus also, the *Ib. leucogaster* of Vieillot (*Gal.* pl. 6), or *Falco formosus* of Latham. Its bill is feeble, and but slightly hooked, and its habits offer a corresponding nonconformity with the usual manners of the raptorial order. It is of a mild and peaceable nature, living, it is said, chiefly on fruits and seeds, with the addition of a few insects, such as ants and locusts. It builds on trees, and utters from time to time a harsh discordant cry. It inhabits Guiana and Brazil, and, exhibiting some of the habits of the toucans, is called by the negroes the *capitaine des gros becs*.

The genus Caracara, Cuv. (*Polyborus*, Vieil.), has the face only partially naked. The *C. Braziliensis* (Plate IV., figure 6) is extremely common in Paraguay.

[1] Geese are also known to have been shot in Newfoundland with their crops full of maize, a species of corn which does not grow but at an immense distance from that island.

Raptores. It lives in pairs, flies rapidly, and preys on birds and small quadrupeds, as well as on insects and reptiles. The female is said to build upon the ground when in the pampas, and on trees when located in wooded countries. This accommodating habit is known to prevail among many other birds.

The three preceding genera, which some regard as forming the *tribe of Caracaras*, are all native to the new world, and may be said to form a link with the vultures, both in regard to the bareness of the face, and their alleged tendency to prey on carrion.

We now proceed to the *tribe of eagles*, of which the bill is very robust, comparatively straight at its basal and middle portion, and suddenly curved at the extremity. It includes the species most celebrated for their strength and courage. Their strong limbs, curved talons, and broad expansive wings, enable them to carry off well-grown lambs, and other bulky prey. They are therefore dreaded by shepherds and such pastoral people, as robbers of the first rank, and a high premium is placed upon their heads accordingly.

In the genus AQUILA properly so called, the bill is shorter than the head, straight, curved at the tip, the edge of the upper mandible with a slight festoon; the nostrils are oblong and oblique; the cere haired; the tarsi short, and covered with feathers. The well-known golden eagle (*A. chrysætos*) affords a characteristic example. This fine British species is widely spread over Europe and America. In our own country it builds on the ledges of mountain precipices—on the Continent its nest is frequently found in forests; for example, in that of Fontainebleau. It is common in the northern and central parts of Europe, but rarer in the south. It is, however well known in Italy. We have seen it sailing over the deep basin of the vale of D'Uomo d'Ossola, and high above the highest snowy peaks which glitter around the majestic passes of the Simplon. In America it breeds among the subalpine districts which skirt the Rocky Mountains, being seldom seen farther eastward. It is regarded by the aborigines as an emblem of strength and courage, and the Indian warrior as well as the highland chieftain glories in his eagle plume. These birds sometimes soar to a vast height, but they seem to do so rather as a kind of sporting exercise, than with a view to search for prey. When employed in hunting, they keep far nearer the earth, sweeping up the valleys, and skirting the sides of heath-covered mountains. The golden eagle is becoming rarer in Scotland every year. Many ancient eyries are pointed out to travellers by gray-haired shepherds, where the bird itself is now no longer known, and in no lengthened period we may expect its extirpation. Several other kinds of feather-footed eagles are known to naturalists, such as the *Aquila imperialis*, a common Egyptian species, not unfrequent in the eastern countries of Europe,—and the *Aquila Bonelli*, a recent acquisition, native to the mountains of Sardinia, and no doubt inhabiting other alpine lands. *Aquila fucosus* is a New Holland species, very common near Port Jackson, and remarkable for its fine wedge-shaped tail.

In the genus HALIÆTUS, or sea-eagle, the bill is nearly as long as the head, and the tarsi are bare of feathers, except at the top. Their habits resemble those of the eagles proper, but they prey more on fish, and will feed more readily on tainted flesh. Species occur in Europe, Asia, Africa, America, and Australia. Our own white-tailed eagle (*H. albicilla*, Plate IV., figure 8) affords a good example. "On observing a person walking near their nests," says Mr Macgillivray, "they fly around him at a respectful distance, sailing with outstretched wings, occasionally uttering a savage scream of anger, and allowing their legs to dangle, with outspread talons, as if to intimidate him. I have observed them thus occupied, when on the edge of a precipice five hundred feet high, with a very steep slope above me, bounded by rocks, and from which I could not have made my escape had the birds been resolute. Although on such occasions they are in general extremely cautious, notwithstanding their manifest anxiety for the safety of their young, yet I once saw an eagle come within an hundred yards, when it was brought down with buckshot by a friend whom I had accompanied to the place."[1] The same writer observes, that he has never heard of the sea-eagle attacking those employed in robbing its nest; but that he has been credibly informed of its having attempted to molest individuals whom it chanced to find among its native crags, in perilous places. In the Hebrides it is itself frequently assailed by the skua-gull; and we have ourselves more than once seen it attacked by the raven. Raptores.

In our present group are many other species, such as the beautiful *Haliætus leucogaster* of New Holland, and the bald or white-headed eagle of America, *H. leucocephalus*. The latter is often seen sailing through and around the gigantic column of spray which rises from that "hell of waters," the cataract of Niagara. Though a bird of powerful wing, he seems to have fallen somehow into lazy habits, or at least prefers the produce of others' labours to his own. "Elevated," says Wilson, "on the high, dead limb of some gigantic tree, that commands a view of the neighbouring shore and ocean, he seems calmly to contemplate the motions of the various feathered tribes that pursue their busy avocations below,—the snow-white gulls slowly winnowing the air,—the busy tringæ coursing along the sands,—trains of ducks streaming over the surface,—silent and watchful cranes intent and wading,—clamorous crows,—and all the winged multitudes that subsist by the bounty of this vast liquid magazine of nature. High over all these hovers one whose action instantly arrests his whole attention. By his wide curvature of wing, and sudden suspension in air, he knows him to be the fish-hawk, settling over some devoted victim of the deep. His eye kindles at the sight, and balancing himself with half-opened wings upon the branch, he watches the result. Down rapid as an arrow from heaven descends the object of his attention, the roar of its wings reaching the ear as it disappears in the deep, making the surges foam around. At this moment the eager looks of the eagle are all ardour; and levelling his neck for flight, he sees the fish-hawk once more emerge, struggling with his prey, and mounting in the air with screams of exultation. These are the signals for our hero, who, launching into the air, instantly gives chase, and soon gains on the fish-hawk; each exerts his utmost to mount above the other, displaying in these rencontres the most elegant and sublime aërial evolutions. The unencumbered eagle rapidly advances, and is just on the point of reaching his opponent, when with a sudden scream, probably of despair and honest execration, the latter drops his fish:—the eagle poising himself for a moment, as if to take a more certain aim, descends like a whirlwind, snatches it in its grasp ere it reaches the water, and bears his ill-gotten booty silently away into the woods."[2] When forced to hunt for themselves, they often attack young pigs, lambs, and sickly sheep.

In the genus PANDION the bill is much shorter than the head; the tarsi are short and naked, covered all round with

[1] *Rapacious Birds of Britain*, p. 60.

[2] *American Ornithology*, vol. i. p. 23. We quote Professor Jameson's *systematic edition*, in four small volumes (Constable's *Miscellany*, 1831). The student of American Ornithology will find some valuable notes by Sir William Jardine, in another Edinburgh edition, in three vols. large 8vo, 1832

Raptores.

imbricated scales; the claws are large and rounded on the under surface, the outer toe very versatile; and the second feather of the wing the longest. Our British osprey, or small fishing eagle, is the *Pandion haliætus*. It breeds in the vicinity of many of our northern sea-lochs, often on the chimney-top of ruined castles by the shore. It destroys a vast quantity of fish, which it secures by thrusting its talons through their backs during a sudden momentary plunge beneath the waves. It is remarkably abundant in North America; and Wilson observes that it permits the purple grakles to build their nests amid the interstices of the sticks of which it has framed its own. He adds, that it never picks up any fish which it may chance to drop either on land or water. We know not if this trait applies to those of the "old country." We once saw an osprey drop a large sea-trout, which it certainly did not attempt to recover; but then there happened at the same time to be an excellent shot, with a double barrel, within a rather dangerous distance of the same. The osprey occurs in New Holland, and is elsewhere very widely spread.

The genus CIRCÆTUS of Vieillot is in a manner intermediate between the fishing eagles, the ospreys, and the buzzards. We may mention as an example the bird called *jean-le-blanc* by the French (*F. Gallicus*, Gmelin), a common continental species.

In HARPYIA, Cuv. the bill is very strong, and compressed, the upper mandible dilated on the margins, and much hooked. The head is crested, the tarsi thick, the wings rather short. The harpies are large birds of prey, which dwell chiefly in the forests of Guiana, making their nests on trees, and committing great depredations. The largest is the *H. destructor* of Daudin (Plate IV., figure 7), said to be capable of cleaving a man's skull by a single blow of its beak. We doubt if any one ever tried. However, it carries off young fawns, and sloths of a year old. It is a rare bird, lately imported to the Zoological Gardens of London, and well exemplified by the specimen in the Edinburgh Museum.

In the genus MORPHNUS of Cuv. (*Spizætus*, Vieillot), the wings are shorter than the tail, the tarsi are lengthened (in some feathered), and the toes feeble. The species are extremely beautiful, and richly varied in their markings. They are chiefly found in South America. We have figured as an example (see Plate IV., figure 9) the *Morphnus cristatus* (*F. Guianensis*, Daud.), which strongly resembles the great harpy just mentioned in its general aspect, but is at once distinguished by its smaller size and longer tarsi. We may mention as an instance of those with plumed tarsi, the *Falco cristatellus* of Temm. *Pl. Col.* 282, which is a native of India and Ceylon.

In CYMINDIS, Cuv. and Temm. the tip of the upper mandible forms a lengthened curve, with a very acute point. The nostrils are obliquely cleft, almost closed; the cere narrow. The tarsi are very short, and reticulated; the wings rather long. The species are South American, and we know of nothing remarkable in their habits. See *Cymindis uncinatus*, Illiger, *Pl. Col.* 103. The extremely hook-billed species (*C. hamatus*, *Pl. Col.* 61) now forms the genus ROSTRHAMUS. Its nostrils are rounded, the space before the eye is bare, and the tarsi are scutellated. Its habits are unknown.

Naturalists differ greatly in their distribution of the preceding genera. Mr Swainson thinks *Circætus* is a subgeneric form of *Gypogeranus*, and he places *Cymindis* with the Caracaras, and certain other groups, in his sub-family *Cymindinæ* or kites, and locates *Morphnus* (*Spizætus*, Vieil.) with the buzzards.

We now proceed to a *third tribe*, consisting chiefly of the sparrow-hawks and goshawks. The bill is curved almost from the base, convex, the upper mandible dilated on the sides, the lower short and obtuse. The nostrils are nearly oval; the tarsi rather long and slender; the claws broad and sharp. The wings have the fourth feather the most extended, and are shorter than the tail. The species are numerous, and occur in all parts of the globe. The larger, which are also proportionally the more robust, with thicker tarsi and shorter wings, have by many Ornithologists been considered as constituting a separate genus, to which the name of ASTUR is applied. That rare British bird the goshawk (*Astur palumbarius*) may be named as a good example, while the smaller and more slender kinds included in the genus NISUS are represented by our sparrow-hawk (*N. communis*, the *Falco nisus* of Linn.). The transition from one to the other is however very gradual, and some deem their separation unwarrantable. Even the two British species, though usually regarded as the types of their respective sections, do not differ so much as to render the propriety of their separation very apparent, even were no other species known. They are all extremely active, as daring as the true falcons, and prey exclusively on living objects, which they seize with admirable dexterity. Their flight is generally low, and as they pass over the fields or woods, they dart upon their prey, whether it be in the air, among branches, or couched upon the ground.[1] The goshawk, though a short-winged species, was formerly held in great estimation for the purposes of falconry. It is one of the most generally diffused of all the accipitrine birds, but is now very rare in Britain. A beautiful white species (*Astur albus*) is found in New Holland. Of the sparrow-hawks we shall allude merely to the *Nisus musicus* of Africa, commonly called the chanting falcon. It is the only raptorial bird in any way gifted with the powers of song; but we must not suppose that its notes at all resemble the harmonious tones of the nightingale, or those of even our less accomplished songsters. Its voice is merely a little clearer than usual, although it seems impressed with a high idea of its own powers, and will sit for half a day perched upon the summit of a tall tree, uttering its incessant cry.

A *fourth tribe* contains the *kites*, which are likewise subdivided into several minor groups, all agreeing in their comparatively feeble bills and feet, their short tarsi, and long extended wings. The tail is forked. They are gifted with great powers of flight, but are neither strong nor courageous, seldom pounce on heavy game, sometimes contrive to prey on fish, and have never the slightest objection to chickens.

In the genus MILVUS of Cuv. is included our common kite (*M. regalis*, Vieil.; *Falco milvus*, Linn.). The tarsi are scutellated in front, and tolerably strong. This beautiful bird is rare in many districts of Scotland, and is scarcely ever seen in the Lothians. We have received it from Argyllshire, but do not think it occurs in the Western Isles. We have often, in the North of England, admired its wheeling flight, circling through the air with no perceptible motion of its long expanded wings, and sailing over that enchanting land of lakes and mountains, with such majestic sweeps as if it were itself "sole king of rocky Cumberland." The kite is distributed over all Europe, but is unknown in America. Other species of the genus occur in Asia, Africa, and New Holland.

In the genus ELANUS of Savigny the tarsi are very short, reticulated, and half clothed with feathers. The wings are long, the tail but slightly forked. It contains *F. dispar* and *melanapterus*, two species which some regard as one and the same. They feed on small birds, insects, and reptiles, and occasionally devour dead animals.

[1] *Rapacious Birds*, p. 231.

Rantores. If identical, the species must exist in America, Africa (occasionally in Europe), and the East Indies. The swallow-tailed kite (*M. furcatus*) forms the genus NAUCLERUS of Vigors. (See Plate V., figure 1.) The form is slender, the tail very long and greatly forked. The species just named is white, with back, wings, and tail black, glossed with green and purple. It inhabits America, at least as far south as Buenos Ayres, and also passes the summer and breeds in the warmer parts of the United States. Tempted by the abundance of the fruitful valley of the Mississippi, a few are seen to wander as far as the Falls of St Antony, in the forty-fourth degree. Audubon states, that in calm warm weather they soar to an immense height, pursuing the large insects (probably libellulæ) called musquito hawks, using their tails with an elegance peculiar to themselves, and performing the most singular evolutions. The Mississippi kite (*F. plumbeus*, Latham) constitutes the genus ICTINIA of the modern systems. It is of a blackish ash colour, the head and under parts of a much paler ashy hue. Wilson frequently observed this hawk in the course of his perambulations, sailing about in easy circles, at a considerable height in the air, and generally in company with Turkey buzzards, with whose mode of flight its own exactly corresponds. It is not easy to say why two birds, whose food and manners are in other respects so different, should so frequently associate in their airy gambols. Though the Mississippi kite feeds chiefly on reptiles and insects, it is a bold and energetic bird. The specimen obtained by Wilson, though wounded, and precipitated from a stunning height, exhibited great strength, and a most unconquerable spirit. He no sooner approached to pick it up, than the bird immediately gave battle, striking rapidly with its claws, wheeling round and round as it lay, "partly on his rump," and defending itself with vigilance and dexterity. Notwithstanding all the aggressor's caution, it struck its hind claw into his hand, with such force as to penetrate into the bone. "Anxious to preserve his life, I endeavoured gently to disengage it; but this made him only contract it the more powerfully, causing such pain that I had no other alternative but that of cutting the sinew of his heel with my penknife." The whole time he lived with Wilson he seemed to watch his every movement, erecting the feathers of his head, eyeing him with fierceness, and no doubt regarding him (and with some show of justice) as the greater savage of the two.

In a *fifth tribe* we may place the honey-hawks, buzzards, and harriers, small groups connected, in a variety of ways, by the usual interlacements, with several of the preceding tribes. The buzzards, for example, both in form and plumage, resemble small eagles, though their bills are more curved from the base;[1] the harriers in some measure connect the buzzards with the accipitrine hawks (gen. *Nisus* and *Astur*); while the honey-hawks (*Pernis*) unite the buzzards to the kites. The natural affinities of groups are in truth so multiplied and complex, that we need scarcely wonder that even those who have most devoted themselves to explore such Cretan labyrinths, should have often failed in their supposed elucidation:—so much the worse for those who have never found the thread.

In the genus PERNIS, Cuv. the lore, or space between the bill and eye, is closely covered by small, compact, rounded feathers, the nostrils are narrow, and the tarsi short, stout, and reticulated. The British bee-hawk (*P. apivorus*), or honey-buzzard as it is usually called, though it cares less for the honey than for those that make it, is of this genus. We have no other indigenous, or indeed European species; but a beautiful crested kind (*P. cristata*, Cuv., Plate V., figure 2) occurs in Java and the East Indies. *P. Elliotii* is also native to the latter country. Raptores.

In the genus BUTEO, Bechstein, the cutting margin of the upper mandible is more flexuous or tooth-like, the gape wider, and the space between the eye and the cere is covered by the same setaceous plumage which usually prevails in that part, the nostrils are rounded, and the tarsi scutellated in front. The buzzards are a numerous genus, distributed over most parts of the world. We have only two British species, the common buzzard (*Buteo vulgaris*), and the rough-legged kind (*B. lagopus*). The latter is a rare or rather accidental visitor, its proper districts being the northern parts of Europe and America. We think buzzards are most abundant in wooded countries. They fly more sluggishly than hawks, and generally rather low, but at times they ascend to a great height, sweeping round in easy circles, and uttering a frequent shrilly cry.

In the genus CIRCUS the bill is slender and compressed, the cere large, the cheeks encircled by a kind of recurved ruff, and the tarsi long, slender, and scutellated before and behind. We have three British species, the moor harrier (*C. æruginosus*), the common ringtail or hen-harrier (*C. cyaneus*, male,—*C. pygargus*, female), and Montagu's harrier (*C. cineraceus*). All these birds roost and breed upon the ground, fly low, and frequent mountainous or marshy places. They prey upon whatever small-sized creatures they can master, whether beast, bird, reptile, or insect. The hen-harrier is supposed to occur in almost all parts of the world, but the identity of the American and European specimens has not been definitely determined. We have figured a foreign species as an example in Plate V., figure 5. It is the *Circus palustris* of Temminck (*C. superciliosus* of some other authors), and a native of Brazil.

We now arrive at the falcons properly so called, or those which have been sometimes distinguished by the appellation of *noble birds of prey*, probably on account of certain members of the group, such as the peregrine and jer-falcon, being held in high esteem as accessaries in the sports of the field. We cannot say that we have been led to our present arrangement by an impression that it is more natural than any other, for we have already left the point which would have conducted us more insensibly into the ensuing nocturnal group of owls; but we do not think it is liable to more grave objections than are many others. Indeed the circular or recurrent nature of the actual affinities of natural groups renders their true exposition, so far as any consecutive system is concerned, impossible; for, instead of advancing, we must necessarily terminate where we began, and therefore either retrace a portion of our circle, or break or bend it, before we can proceed to another. Without, therefore, desiring the reader to suppose that the harriers in any special way conduct him to the falcons, we shall give a brief notice of the latter.

The falcons are chiefly distinguished by the strong, tooth-like notching of the bill, which in the preceding groups is either entirely absent, or shows itself only in the form of a more or less distinct festoon.[2] The first quill-feather is always long, the second longer than the third and fourth, so that the wing acquires a sharp or pointed form, instead of the rounded outline of the so-called ignoble tribes; and the points of the wings, when closed, usually attain to the end of the tail.

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[1] Mr Macgillivray mentions, that the digestive organs of the common buzzard so greatly resemble those of the golden eagle, that a figure of the one might serve for that of the other.

[2] It is, we believe, in vain that naturalists attempt exceptionless precision in their generalities; for, in this very group, the jer-falcon, in one sense the *noblest* of all, frequently wants the tooth, and exhibits a bill festooned like the eagle's.

Raptores. In the restricted genus FALCO, then, the bill is short, but strong, conical, curved from the base, sharply hooked at the extremity, and almost always toothed as well as pointed; the nostrils are rounded, the cere bare, or merely encroached upon by the bristly feathers of the lore. The tarsi are rather short and strong, and covered with scales of somewhat variable form, but usually rounded or angular. The wings are long and pointed. We have four well-known British species, the peregrine falcon (*F. peregrinus*), the hobby (*F. subbuteo*), the merlin (*F. æsalon*), and the kestril (*F. tinnunculus*). Besides these, we may name the jer-falcon (*F. islandicus*, Plate V., figure 4) as an occasional, and the orange-legged hobby (*F. vespertinus*) as an accidental visitor. The jer-falcon, in spite of its alleged want of teeth, is one of the boldest and most powerful of the class. This fine species seems now confined almost entirely to the most northern parts of Europe and America. It is well known in Iceland and Greenland, and was often seen by Dr Richardson during his journeys over the "barren grounds" of North America, where it preys habitually on ptarmigan, not, however, despising plovers, ducks, and geese. "In the middle of June," he observes, "a pair of these birds attacked me as I was climbing in the vicinity of their nest, which was built on a lofty precipice on the borders of Point Lake, in latitude 65½°. They flew in circles, uttering loud and harsh screams, and alternately stooping with such velocity that their motion through the air produced a loud rushing noise; they struck their claws within an inch or two of my head. I endeavoured, by keeping the barrel of my gun close to my cheek, and suddenly elevating its muzzle when they were in the act of striking, to ascertain whether they had the power of instantaneously changing the direction of their rapid course, and found that they invariably rose above the obstacle with the quickness of thought, showing equal acuteness of vision and power of motion. Although their flight was much more rapid, they bore considerable resemblance to the snowy owl."[1] Upon the whole, we think that Great Britain and Ireland are just as well quit of such a fierce intruder. The Doctor adds, that when the jer-falcon pounces down upon a flock of ptarmigan, the latter endeavour to save themselves by diving instantly into the loose snow, and making their way beneath it to a considerable distance.

A few species, in which the toothing of the upper mandible is double, form the genus BIDENS of Spix, synonymous, we presume, with *Harpagus* of Vigors. Such are *F. bidentatus*, Lath., *F. diodon*, Temm. *Pl. Col.* 198. In IERAX of Vigors, the upper mandible seems as strongly and sharply bidentated as in the preceding, but the under one is simply notched, as in the true falcons, and the second quill-feather of the wing is the longest. This genus includes the beautiful little finch-falcon of Bengal, *F. cærulescens*, the smallest of the hawk tribe. An elegant crested kind from Pondicherry serves as a type to the genus LOPHOTES.

We shall conclude this section by a brief indication of that remarkable bird, the secretary, or serpent-eater of Southern Africa—the *Gypogeranus serpentarius* of Illiger. (See Plate V., figure 9.) Its affinities have been in no way satisfactorily illustrated, and each author has hitherto placed it according to his own fancy. Baron Cuvier locates it between the buzzards and the owls; M. Lesson makes it a "gallinaceous accipiter," in strange company with the horned screamer (*Palamedea cristata*) of Brazil; while Mr Swainson is now satisfied that it is no other than "the rasorial type of the aquiline circle." Be this as it may, it has a strong, well-curved bill, a crested head, a lengthened neck, and long, slender, crane-like legs. It is Raptores. the only one of its genus, and has been designated by a variety of names. Some call it the messenger, because it runs with great rapidity, which few actual messengers ever do; others name it the secretary, because it has a pen-like plume behind its ear, where a secretary's pen should never be; while its frequent title of serpent-eater is probably better earned, by its useful habit of devouring those dangerous reptiles. Its diet, however, seems to be of a rather miscellaneous nature, as Le Vaillant found in the stomach of a single specimen twenty-one young tortoises, three snakes, and eleven lizards, besides which there was a large ball in the stomach, formed entirely of the scales of tortoises, the vertebræ of snakes and lizards, the legs of locusts, and the wing-cases of coleopterous insects. "In his habits," says Mr Bennet, "he partly resembles both the eagle and the vulture, but differs from them most completely in the nature of his prey, and in his mode of attacking it. Like the former, he always prefers live flesh to carrion; but the food to which he is most particularly attached consists of snakes and other reptiles, for the destruction of which he is admirably fitted by his organization. The length of his legs not only enables him to pursue these creatures over the sandy deserts which he inhabits, with a speed proportioned to their own, but also places his more vulnerable parts in some measure above the risk of their venomous bite; and the imperfect character of his talons, when compared with those of other rapacious birds, is in complete accordance with the fact, that his feet are destined rather to inflict powerful blows than to seize and carry off his prey. When he falls upon a serpent, he first attacks it with the bony prominences of his wings, with one of which he belabours it, while he guards his body by the expansion of the other. He then seizes it by the tail, and mounts with it to a considerable height in the air, from which he drops it to the earth, and repeats this process until the reptile is either killed or wearied out; when he breaks open its skull by means of his beak, and tears it in pieces with the assistance of his claws, or, if not too large, swallows it entire. Like the eagles, these birds live in pairs, and not in flocks; they build their aiery, if so it may be termed, on the loftiest trees, or, where these are wanting, in the most bushy and tufted thickets. They run with extreme swiftness, trusting, when pursued, rather to their legs than to their wings; and as they are generally met with in the open country, it is with difficulty that they can be approached sufficiently near for the sportsman to obtain a shot at them. They are natives of the south of Africa, and appear to be tolerably numerous in the neighbourhood of the Cape, where, it is said, they have been tamed to such a degree as to render them useful inmates of the poultry-yard, in which they not only destroy the snakes and rats which are too apt to intrude upon those precincts, but even contribute to the maintenance of peace among its more authentic inhabitants, by interposing in their quarrels, and separating the furious combatants who disturb it by their brawls."[2]

SECT. II.—NOCTURNAL BIRDS OF PREY.

The great raptorial division called owls are usually distinguished by the comparative largeness of their heads, the anterior portion of which is surrounded by a peculiar circle of feathers forming a facial collar, to which they owe the most marked and peculiar feature of their physiognomy. The bill is curved almost from the base, where it is greatly enveloped by setaceous feathers, which fre-

[1] *Fauna Boreali-Americana*, part ii. p. 28.

[2] *Tower Menagerie*, p. 211.

Raptores. quently cover or conceal the cere and nostrils. The eyes are large, and so placed that vision is directed rather forwards than laterally, and are furnished with a nictitating membrane. The tarsi, and even the toes, are closely covered by short downy or hairy feathers. The outer toe is versatile; the claws extremely sharp. The plumage is remarkable for its great softness. The concha of the ear is for the most part very large; and from this we may infer that the sense of hearing is acute.

The greater proportion of the species hunt by night, or during the sweet but sombre hours of twilight. Their flight is light, buoyant, noiseless, and performed by slow but regular flapping of the wings. Their food, like that of most birds of prey, is various; but we believe they prefer mice and similar small quadrupeds, probably because the habits of these minute creatures are, like their own, nocturnal. Owls are solitary, seldom more than a pair being found together, although the woodcock owl (*Otus brachyotus*) is found during autumn in small conjoined family flocks of ten or twelve together; and the Arkansa owl of America is likewise in a manner gregarious. "There is something," says Wilson, "in the character of the owl so recluse, solitary, and mysterious, something so discordant in the tones of its voice, heard only amid the silence and the gloom of night, and in the most lonely and sequestered situations, as to have strongly impressed the minds of mankind in general with sensations of awe and abhorrence of the whole tribe. The poets have indulged freely in this general prejudice; and in their descriptions and delineations of midnight storms, and gloomy scenes of nature, the owl is generally introduced to heighten the horror of the picture."

The systematic arrangement of these nocturnal birds of prey is as yet unsatisfactory. The following is a brief view of Baron Cuvier's system.

The genus Otus has two well-marked aigrettes, or tufts of feathers, on the front of the head, capable of being depressed or raised at pleasure, and the conch of the ear extends semicircularly from the beak almost to the top of the head, and is furnished in front with a membranous opercle. Two British species may be here placed, the long-eared or horned owl commonly so called (*Strix otus*), and the short-eared owl (*Strix brachyotus*). The genus Ulula consists of species resembling the preceding in the bill and auditory opening, but not possessed of aigrettes. Such is the great northern species (*S. Laponica*, Gm.). The genus Strix properly so called has also large ear-openings, and wants the aigrettes, but is distinguished by the bill being comparatively straight at the base, and curved towards the extremity. The facial disk is strongly marked, the tarsi are feathered, and the toes are haired. Example, *Strix flammea*, our barn or white owl. In the genus Syrnium, the facial disk is formed of decomposed or unwoven feathers, the collar is also large, and the aigrettes wanting, but the toes are feathered. (See Plate V., figure 6.) The brown or wood owl of Britain (*S. aluco* and *stridula*, Linn.) is placed here The genus Bubo has the facial disk less marked, the aigrettes conspicuous, and the toes feathered. The great eagle owl of Europe (*B. maximus*, *S. bubo*, Linn.) affords a good example. It inhabits the larger forests of Russia, Hungary, Germany, and Switzerland, becoming very rare in France, disappeariug altogether in Holland, and visiting Great Britain as it were by chance. Here also may be placed the great horned owl of America, *S. Virginiana* (Plate V., figure 8), which occurs in almost every quarter of the United States, and spreads into the far fur-countries of the north, wherever there is timber of sufficient size to serve the purposes of nidification. His favourite residence, however, according to Wilson, is the dark solitudes of deep swamps, covered by a growth of gigantic timber, from whence, so soon as evening darkens, and the human race retire to rest, he sends forth his unearthly hootings, startling the way-worn traveller by his forest fire, and "making night hideous." "Along the mountainous shores of the Ohio, and amidst the deep forests of Indiana, alone, and reposing in the woods, this ghostly watchman has frequently warned me of the approach of morning, and aroused me by his singular exclamations, sometimes sweeping down and around my fire, uttering a loud and sudden *waugh o! waugh o!* sufficient to have alarmed a whole garrison. He has other nocturnal solos, no less melodious, one of which very strikingly resembles the half-suppressed screams of a person suffocating or throttled, and cannot fail of being exceedingly entertaining to a lonely benighted traveller in the midst of an Indian wilderness."[1] The genus Noctua consists of species in which the tufts or aigrettes are wanting, the concha of the ear small, with an ordinary-sized opening. The facial disk is likewise small and incomplete. This gives the countenance a more hawk-like physiognomy; and in accordance with this expression, we find the habits of the species naturally more diurnal than those of many other owls. We here place the northern *Harfang*, or great snowy owl (*Strix nyctea*, Linn.), one of the most beautiful of the group, an occasional visitant of Great Britain, and not very unfrequent in the Orkney and Shetland Islands. It is a common inhabitant of the arctic regions of both the old and new world, from which it migrates on the approach of winter, but without passing to the southward of the colder portions of the temperate zone. It frequently hunts by day; and indeed if it did not so, what would become of it in those far northern countries where a "sleepless summer of long light" knows not for months the refreshing influence of nocturnal darkness? It preys not only on quadrupeds and birds, but frequently strikes its talons into fish, and bears them astonished from their moist abode into the leafy recesses of the forest. There are few things more out of place than a trout on the top a large tree. Its own flesh is said to be white and well flavoured; and when in good condition, is eaten both by the native Indians and the white residents in the fur-countries. Several of the smaller owls are included in the present genus, such as *Strix passerina*, Linn. In the genus Scops (Plate V., figure 7) the toes are naked, and the head furnished with tufts; and in certain peculiar foreign species of considerable size, the tarsi (a very unusual character) are bare and reticulated. These have been formed of late into a genus called Ketupa. Example, *Strix Ketupa*, Horsfield, Temm. *Pl. Col.* 74.

Raptores.

One of the most curious of owls, in its habits, is the burrowing species of the new world—*Strix cunicularia* of Bonaparte. Its particular genus has not yet been determined. These birds inhabit the burrows of the marmot, and consequently dwell in open plains. They seem to enjoy even the broadest glare of the noon-day sun, and may be seen flying rapidly along in search of food or pleasure during the prevalence of the cheerful light of day. They manifest but little timidity, allow themselves to be approached sufficiently close for shooting, and though some or all may soar away, they settle down again at no great distance. If further disturbed, they either take a more lengthened flight, or descend into their subterranean dwellings, from whence they are dislodged with difficulty. When the young are only covered with down, they frequently ascend the entrance to enjoy the warmth of the mid-day sun; but as soon as they are approached, they quickly retire within their burrow. In North America the burrowing owl feeds

[1] *American Ornithology*, i. p. 101.

Insessores. chiefly on insects—in the West Indies (if the species are identical), on rats and reptiles.

Order II.—INSESSORES or PERCHING BIRDS.[1]

This is the most numerous order of the class of birds, and, as Cuvier has observed, is distinguished chiefly by negative characters; for it embraces all those various groups which, sometimes possessing but little in common, are yet in themselves neither raptorial, scansorial, grallatorial, natatorial, nor gallinaceous. At the same time they exhibit a general resemblance to each other in structure, and present such gradual transitions from group to group, as to render definite subdivisions by no means easy.

They are said to possess not the violence of birds of prey,—meaning thereby our preceding accipitorial order. Yet a fly-catcher crushing the body of a slender-limbed and delicate gnat, a blackbird pertinaciously dragging a reluctant worm from its subterranean dwelling, or a sparrow with his bill as full of tortuous caterpillars as it can contain (to say nothing of the butcher-bird, which is said to impale his prey alive upon "the blooming spray"), is assuredly as raptorial or predaceous as need be well desired. Neither can the division of the smaller birds into granivorous and insectivorous be strictly maintained, though we doubt not that the strong, conical billed species eat most greedily of seeds and grain, while those of softer and more slender bill are chiefly avidous of insect life;—but all precise divisions, founded on the love of any special diet, must be received with reservation,—seeing that almost all passerine birds feed both themselves and young in spring and early summer with what may be correctly called animal food (that is, insects and worms), while in autumn and throughout the winter season they just as generally (and for the best of reasons) have recourse to all manner of seeds and grain. The tender-billed birds are certainly more dependent on insect food than the others, and it is consequently among them that we find the greater proportion of our migratory species; for as the increasing chillness of autumn depopulates the busy world of insect life, so our finest songsters (the familiar red-breast forming a delightful exception) take then their departure for other climes, not so much by reason of the immediate influence of cold upon themselves, as because they find their accustomed food becoming daily less abundant. Such of the insectivorous tribes as remain with us throughout the year assuredly combine the graminivorous diet with their more favourite food, just as the hard-billed species sustain themselves during spring and summer by the capture of insects. In tropical countries, where the seasons are less strongly or differently marked, and the death-like torpidity of our northern winters is unknown, this periodical change of food may probably either not obtain, or be less perceptible in its occurrence; but as we know that over a great part of the globe it is true, that for one portion of the year most insect-eating birds feed on seeds, and that for another portion of the year most seed-eating birds feed on insects, we may be permitted to doubt the propriety of rigorously dividing the great body of passerine species into insectivorous and granivorous sections. We admit that, either from the nature of things, or the feebleness of human language, the terms applied to the greater divisions of natural history ought not to be construed according to their strictest literal interpretation, as they are frequently of a conventional character, and have in some cases been substituted for numerical signs, as more easily held in remembrance; but it is nevertheless to be greatly desired, that those who are influential in the nomenclature of science should avoid bestowing appellations which convey an erroneous idea of the objects intended to be expressed. Insessores.

The feet of the insessorial order are especially formed for perching, the hind toe springing from the same plane as the anterior ones,—a structure which gives them great power in grasping. Their legs or tarsi are always of moderate length, and the claws not strongly curved. The form of the bill is too various to be generalized; and the same may be said of the length of the wings, of which the comparative breadth generally bears relation to the habit of life of each particular tribe. The stomach is in the form of a muscular gizzard, generally preceded by a greater or less expansion in the shape of crop, and there are usually two very small cæca. The lower larynx is very complicated, especially among the various tribes of songsters. We must now rest satisfied with these brief and barren generalities. "The great order of Passeres or Insessores of authors," Mr Macgillivray observes, "is so heterogeneous in its composition, that all who have attempted to characterize it, whether in few or in many words, have utterly failed; for this plain reason, that its various groups are as unlike to each other as they are to the Raptores or Rasores, and that in fact the only common features which they exhibit are those of the general organization of birds. A hornbill and a humming-bird, a parrot and a wren, a kingfisher and a swallow, a starling and a toucan, not to mention others still more dissimilar, are surely as unlike each other as a hawk and a shrike, a pigeon and a plover, or a flamingo and a pelican."[2]

The first principal division of the passerine birds consists of those genera in which the external toe is united to the internal by not more than one or two of the joints, and contains the four great tribes of *Dentirostres*, *Fissirostres*, *Conirostres*, and *Tenuirostres*.

Tribe Ist.—Dentirostres.

Bill with a marginal notch towards the extremity of the upper mandible.

The dentirostral tribe is composed chiefly of insectivorous groups, and, according to the modern views, contains the following five families, viz. *Laniadæ*, *Merulidæ*, *Sylviadæ*, *Ampelidæ*, and *Muscicapidæ*. We do not think the general reader, with whose tastes the treatises in our Encyclopædia are for the most part made to conform, would be benefited by our entering into the complexities of these circular arrangements, or by an extended exposition of the innumerable minor groups of which the families are composed. We shall therefore here content ourselves by noticing the principal generic groups which form as it were the groundwork on which the more elaborate systems have been erected, and with which it is necessary to become familiar in their more general and comprehensive form, before their minuter subdivisions (to be elsewhere studied) can be understood. The genera are chiefly determined by the form of the bill, which is strong and compressed among the shrikes and thrushes, depressed in the fly-catchers, rounded and thickish in the tanagers, slender and pointed in the warblers,—but in each and all exhibiting different degrees of the typical character, or a tendency to transition, which admits of various systematic views.

Mr Swainson divides the Laniadæ or shrikes into five sub-families, viz. *Lanianæ*, or true shrikes; *Thamnophilinæ*, or bush-shrikes; *Dicrurinæ*, or drongo shrikes; *Ceblepyrinæ*, or caterpillar catchers; and *Tyranninæ*, or tyrant shrikes; and each of these contains a great variety of ge-

[1] Picæ and Passeres, Linn.

[2] *British Birds*, vol. i. p. 311.

Insessores. nera and subgenera. We shall here follow the outlines of Baron Cuvier's system, which we shall illustrate by occasional figures.[1]

In the genus LANIUS, the bill is of moderate size, but strong, somewhat triangular at the base, and laterally compressed. In the European species (which we call butcher-birds) the upper mandible is somewhat arched. Three of these (*Lan. excubitor, collurio,* and *rufus*) are natives of England, but the first and last are very rare. The food of butcher-birds consists chiefly of insects, but they attack occasionally the smaller kinds of birds and quadrupeds. Their mode of flight is irregular, the tail being kept in constant agitation. The sexes differ from each other in their plumage, and the immature birds bear a resemblance to the adult females. In most of the species the moult is single, in others double, that is, certain parts of the plumage are changed twice a year. Our great cinereous shrike (*L. excubitor*) destroys its larger prey by strangulation, and transfixing it after death upon a thorn, tears it into smaller parts at leisure. This wise but somewhat savage instinct seems implanted in the bird to make amends for the comparative weakness of its feet and claws. "This singular process," says Mr Selby, "is used with all its food. I had the gratification of witnessing this operation of the shrike upon a hedge accentor (*A. modularis*) which it had just killed; and the skin of which, still attached to the thorn, is now in my possession. In this instance, after killing the bird, it hovered with the prey in its bill for a short time over the hedge, apparently occupied in selecting a thorn fit for its purpose. Upon disturbing it, and advancing to the spot, I found the accentor firmly fixed by the tendons of the wing at the selected twig. I have met with the remains of a mouse in the stomach of a shrike; and Montagu mentions one in which he found a shrew."[2]

We have figured, in illustration of the genus Lanius, the species called *fiscal* (*L. collaris*) by Vaillant. (See Plate VI., figure 1.) When this bird sees a locust, mantis, or small bird, it springs upon it, and immediately impales it on a thorn, with such dexterity, that the spine always passes through the head. It is a bold, vindictive, noisy, and even cruel bird, for it seems to kill many more victims than it actually requires for food. These are found transfixed on many a neighbouring bush and tree, the major part often so destroyed by dryness as to be totally unfit for food.

Some foreign species, in which the upper ridge of the bill is straight, and the point only curved, form the genus THAMNOPHILUS of Vieillot. The Thamnophili inhabit chiefly the tropical regions of the new world, but some of the species have an extensive range, from Canada as far southwards as Paraguay. In *Tham. guttatus* of Spix the bill is very strong, and the inferior mandible inflated. In others it is straight and slender, with its base adorned with reversed setaceous feathers. Such is *L. plumatus*, an African species, which forms the genus PRIONOPS of Vieillot.

In the genus VANGA (Plate VI., figure 3) the bill is large, greatly compressed throughout, the point of the upper mandible suddenly curved, the under mandible bent upwards. Example, *Lan. curvirostris*, Gmelin. In OCYPTERUS, Cuv. the bill is conical, rounded, scarcely arched towards the point, the termination very sharp and fine, slightly notched. The legs are rather short, and the wings long, from which characters the species have obtained the name of swallow butcher-birds; but they are as courageous as other shrikes, and do not fear to attack even crows. The species are numerous along the shores and islands of the Indian Seas, where they exhibit great agility in the capture of their insect prey. Ex. *Lan. leucorhynchos*, Gm. In BARYTA of Cuv. the bill is large, conical, straight, round at the base, and encroaching on the forehead by a circular notch; the ridge is rounded, the sides compressed, the point curved. The nostrils are small and linear. The species of this genus, as well as those of Vanga, are by some combined with the crows, as part of the conirostral tribe. We may name, as an example, the piping grakle of the older writers (*Coracias tibicen*, Lath.), a native of New Holland, where it is known by the name of *Jarra-war-nang*. It preys on small birds, and is said to have a melodious voice, resembling the tones of a flute. The genus CHALYBÆUS, Cuv. has the bill resembling the preceding, but rather thicker at the base, and the nostrils are pierced in a broad membranous space. (See Plate VI., figure 6.) The species are natives of New Guinea, and are remarkable for their beautiful tints of burnished steel. *C. paradisæus* has the feathers on the head and neck like frizzled velvet, and was first described by Sonnerat as a bird of paradise,—*Par. viridis*, Gmelin. In PSARIS of Cuvier the bill is conical, thick, round at the base, but not encroaching on the front, slightly compressed, and curved at the extremity. The genus is founded on the Cayenne shrike of Latham, *Lanius Cayanus*, Linn.[3] It now contains many species, all classed by Mr Swainson among the Muscicapidæ or fly-catchers. Their habits are said to resemble those of the butcher-birds. The genus GRAUCULUS, Cuv. has the bill less compressed than in Lanius, the upper ridge sharp, equally curved throughout its whole extent, the commissure or cutting edges also slightly bent. The hairs which sometimes cover the nostrils ally these species to the crows, from which they are distinguished by the notching of the bill. Their prevailing hues are ash-colour, and they are native to the Indian islands. Cuvier here places the beautiful *Irena puella* of Dr Horsfield, a Javanese species, of a fine velvet black, the back splendid ultramarine blue. It is ranged by others with the Orioles. To the same genus he likewise refers the Papuan and New Guinea crow (*C. papuensis* and *Novæ Guineæ*), and the *Piroll* of Temminck, of which the male and female differ so remarkably, the former being of a glossy blue, the latter greenish. This last species forms the genus *Ptilonorhynchus* of Kuhl,—*Kitta* of M. Lesson. It is the satin-bird of the colonists of Port Jackson, a solitary, fearful creature, which seldom leaves the cover of the umbrageous woods. The Australian natives call it *cowry*.

In BETHYLUS, Cuv., the bill is thick, short, bulged, slightly compressed towards the end. Its type is the magpie-shrike of Latham, *L. picatus*, an inhabitant of Guiana and Brazil. (Plate VI., figure 2.) In FALCUNCULUS the bill is much compressed, almost as high as long, the culmen arched. It contains the *Lanius frontatus* of New Holland. The genus PARDALOTUS (which M. Lesson places with the tit-mice, and Mr Swainson with the manakins) is likewise constituted by a New Holland species, the *Pipra punctata* of Shaw. The bill is short, obtuse, convex, and slightly compressed.

All the preceding genera of the dentirostral tribe are supposed by Baron Cuvier to be more or less allied to *Lanius* of Linnæus. A great diversity of opinion, however, exists regarding their natural distribution; and in the most recent systems they will be found differently

Insessores

[1] For more minute details, the student may consult Mr Swainson's "Inquiry into the Natural Affinities of the Laniadæ or Shrikes," *Zoological Journal*, No iii. p. 289.

[2] *Illustrations of British Ornithology*, vol. i. p. 149.

[3] See *Zool. Journal*, No. vii. p. 354, and No. viii. p. 483.

Insessores. and variously disposed. according to the views of each particular author.

Many of the genera next ensuing are more allied to the fly-catchers, *Muscicapidæ;* but not a few are classed by recent writers among the *Laniadæ* and *Ampelidæ*. The bill is of medium size, broad at the base, horizontally depressed, almost straight, generally wider than high, the point more or less hooked and notched. The mouth is garnished with bristly feathers projecting forwards. Their food varies according to their size and strength,—the more powerful species seizing occasionally on small birds as well as insects, the more feeble being satisfied with the latter kind of prey.

In the genus TYRANNUS, Cuv., the bill is straight, lengthened, strong, the culmen rounded, the point suddenly hooked. (See Plate VI., figure 5.) The species consist chiefly of Linnæan fly-catchers, with a few shrikes. They are all native to America, and, as their name implies, are fierce and domineering in their disposition. They will defend their young against the boldest aggressor, and have been seen to drive from their nesting-places even the largest birds of prey. As an example, we may here name the king-bird, or tyrant fly-catcher, of the new world, *T. intrepidus*. This species is one of the most remarkable for the boldness and intrepidity which he displays in his attacks on the strongest of the feathered race. During the earlier months of summer, indeed, his life is one continued scene of broil and battle. According to Wilson, hawks and crows, the bald eagle, and the great black eagle, all equally dread an encounter with this dauntless creature, who, as soon as he perceives a bird of prey, however powerful, in his neighbourhood, darts into the air, and quickly ascending above his supposed enemy, pounces with violence upon his back, and continues his attack till his own domains have been departed from. He is likewise in some measure obnoxious to the human race, on account of his love of bees; for he will take post on a fence or garden-tree in the vicinity of hives, and make continual sallies on the industrious tenants, as they pass to and from their never-ceasing labours. His great American biographer, however, is of opinion, that whatever prejudice may prevail against him for such depredations, he is on the whole greatly the friend of man, by destroying multitudes of insects, whose larvæ prey on the produce of the field and garden. The tyrant has been immortalised in verse as well as prose:

> Far in the south, where vast Maragnon flows,
> And boundless forests unknown wilds enclose,
> Vine-tangled shores and suffocating woods,
> Parch'd up with heat, or drown'd with pouring floods;
> Where each extreme alternately prevails,
> And nature sad their ravages bewails;
> Lo! high in air above those trackless wastes,
> With spring's return the king-bird hither hastes;
> Coasts the famed gulf, and from his height explores
> Its thousand streams, its long indented shores,
> Its plains immense, wide opening on the day,
> Its lakes and isles, where feather'd millions play:
> All tempt not him: till gazing from on high,
> Columbia's regions wide below him lie;
> There end his wanderings and his wish to roam,
> There lie his native woods, his fields, his home;
> Down, circling, he descends from azure heights,
> And on a full-blown sassafras alights.
>
> Fatigued and silent, for a while he views
> His old-frequented haunts, and shades recluse;
> Sees brothers, comrades, every hour arrive,—
> Hears, humming round, the tenants of the hive;
> Love fires his breast,—he woos, and soon is blest,
> And in the blooming orchard builds his nest.

The king-bird migrates in summer at least as far north as the fifty-seventh parallel. It reaches Carlton House in the month of May, and retires southward in September. A new species has been of late years discovered on the banks of the Saskatchewan, but nothing is yet known of its habits. It is described by Mr Swainson under the title of *Tyrannus borealis*. It is considerably smaller than the preceding, and may at once be distinguished by its forked tail, not tipped with white.[1] The other species are numerous.[2] Insessores.

A still more extensive genus is that named MUSCIPETA, Cuv. The bill is long, much depressed, twice as broad as high even at the base, the culmen usually very blunt, the margins forming an oval curve, the point feebly notched, and the base covered by long, setaceous feathers. The general form of the species is feeble compared with that of the preceding, and they prey exclusively on insects. They are extremely beautiful, often adorned by crests upon the head, or by gracefully elongated feathers in the tail. The majority are native to Africa and India. The paradise fly-catcher of Le Vaillant may be named as an example.

In the genus PLATYRHYNCHUS of Desm., the bill is short, and still broader and more depressed than in the preceding. *P. cancromus* inhabits Brazil. These birds are by some conjoined with *Todus*, to which they are assuredly allied. Certain species, of which the feet and legs are long and slender, and the tail extremely short, form the genus CONOPHAGA of Vieillot. The fly-catchers properly so called, genus MUSCICAPA, Cuv., have the beard or bill-feathers less extended than in *Muscipeta*, and the bill itself is narrower, the ridge or culmen is distinctly marked, the margins straight, the point slightly bent. The species are peculiar to the ancient continent, and not more than four or five occur in Europe. Of these, two are British, *M. grisola*, or the spotted fly-catcher, a well-known and common species; and *M. luctuosa*, or the pied fly-catcher, which is very rare. We have seen it on the banks of the Eden in Cumberland. Both are birds of passage. The species of this genus take their insect prey upon the wing, darting upon it at intervals from some favourite twig. The males and females differ considerably in their markings, especially in spring and summer, although the former sex (at least in *M. albicollis*, Temm.) are scarcely to be distinguished from the latter throughout the winter season. The modifications in the form of the bill in this extensive genus have led to the formation, so far as concerns exotic species, of a vast number of sectional groups, or subgenera, the characters of which we cannot here detail.

We now arrive, in accordance with Baron Cuvier's system, though not, we fear, by natural transition, at the genus GYMNOCEPHALUS, of which the beak resembles that of *Tyrannus*, except that the ridge is more arched, and a great portion of the face is bare of feathers. (See Plate VI., figure 8.) There seems to be only a single species, commonly called the bald crow (*G. calvus*), a bird about the size of a rook, of a uniform tobacco-brown colour, the feathers of the wings and tail black. It is called *oiseau mon prère* by the Creoles of Cayenne, probably from its capucin aspect. Its bald front bestows upon it a very singular physiognomy. Vaillant regards the absence of feathers on that part as accidental; and he mentions in a note,[3] that he received a specimen from Cayenne, in which the face was plumed. But M. Lesson states that he has examined more than twenty specimens, and has always found the face unfeathered.

The genus CEPHALOPTERUS, on the contrary (see Plate

[1] See *Fauna Boreali-Americana*, part ii. pl. lxxxv.
[2] Consult Mr Swainson's "Monography of the Tyrant Shrikes of America," *Journal of the Royal Institution*, No. xl.
[3] *Histoire des Oiseaux de Paradis*, t. i. p. 109.

Insessores. VI., figure 4), has the front adorned by a very peculiar tuft of feathers, which, rising upwards, and then spreading around and drooping downwards, shades the head, as it were, beneath a parasol. Another expanded and lengthened set of plumes hangs in an apron-like fashion from the breast. The prevailing plumage is deep black, the parts first mentioned having a metallic lustre. The bill of the only species known (*C. ornatus*) is robust, the mandibles nearly equal, the upper being convex, without notch, and scarcely bent at the extremity. This bird was *brought* to Paris, from the Lisbon Collection, by M. Geoff. St Hilaire, and was believed to have been sent originally from Brazil. As that country, however, has been so much explored without the Cephalopterus having ever since been met with, it is more likely, M. Temminck thinks, to have been obtained in the less-frequented countries of Peru, or the coast of Chili. On the other hand, M. Lesson alleges, that he was informed by a well-instructed Portuguese, that the bird in question came from Goa. It is the *Coracina cephaloptera* of M. Vieillot. We have no doubt it is a South American species.

From these singular birds we proceed to the Cotingas or chatterers, genus AMPELIS, Linn., a varied and beautiful family, now partitioned into several minor groups. They have all the depressed bill of the fly-catchers in general, but it is rather shorter in proportion, broadish, and slightly arched.

Those in which the bill is the strongest and most pointed, with dilated margins, are characterized by an insectivorous regime. These are the *piahaus* of South America, genus QUERULA, Vieil. The species fly in troops through the forests. Here are placed the *Cotinga rouge* of Vaillant, or *Ampelis phœnicia*, also the *Ampelis cinerea* and *Muscicapa rubricollis* of Gmelin. In the ordinary Cotingas (or genus AMPELIS properly so called) the bill is more feeble, little elevated, deeply cleft. The species inhabit moist places, and are remarkable for the rich and lustrous plumage of the males during the breeding season. We here place the *Ampelis pompadoura, carnifex*, and *cotinga*, Linn. In the genus BOMBYCILLA, Brisson, which includes our European or Bohemian chatterer, the head is ornamented by an elongated crest, and the majority of the species have the secondary feathers of the wings terminated by a small oval expansion, resembling a bit of scarlet sealing-wax. These birds prefer wild fruits to insects. The appetite of the American species (*A. Americana*) is stated by Mr Audubon to be of so extraordinary a nature as to prompt it to devour every fruit and berry in its way. In this manner it will gorge itself to such excess as to be sometimes unfit to fly, and may then be taken by the hand. "I have seen some which, though wounded and confined to a cage, have eaten apples until suffocation deprived them of life."[1] Our author adds, however, that they are also excellent fly-catchers, spending much of their time in pursuit of winged insects. They become very fat during the fruit season, and are then so tender and juicy as to be much sought for as an article of epicurean diet. They inhabit the United States throughout the year. The habits of the European wax-wing (*A. garrula*) are much less known. It not unfrequently visits Britain during winter, and is supposed to breed within the arctic circle. It likewise inhabits North America, but has not been observed to the southward of the fifty-fifth parallel. Dr Richardson observed a flock of three or four hundred on the banks of the Saskatchewan in May. During their trips to Britain they feed, when they can get them, on the berries of the mountain ash; and Sir William Jardine found the stomachs of one or two killed near Carlisle to be crammed with holly berries. A third species was some time ago discovered by Dr Seibo.d in Japan. It is the *B. phœnicoptera* of Temminck, and wants the wax-like appendages to the wings. Insessores.

In the genus CASMARHYNCHUS, Temm., the bill is remarkably broad, greatly depressed, soft and flexible at the base, of a harder consistence, and somewhat compressed towards the extremity. The nostrils are large and open, and placed far forward on the bill. As an example, we may name that singular bird the araponga (*Cas. nudicollis*, Temm. *Pl. Col.* 368–83), a Brazilian species, remarkable for the metallic resonance of its cry, which sounds like the clinking of a blacksmith's hammer. By reason of this peculiarity, it is known to the Brazilians by the name of *O. ferrador*, or the blacksmith. The adult male is pure white, the face and front of the neck nearly bare, of a green colour, sprinkled with a few small black feathers. The female is green, spotted on the under parts with white, the upper plumage of the head nearly black. The young at first resemble the mother, and adolescent males are found with a mingled plumage of green and white. Another species, of nearly corresponding plumage, is distinguished by a long, fleshy, sometimes slightly feathered caruncle, hanging from the basal front of the upper mandible. It is erectile, and sometimes projects upwards. This is the *Ampelis carunculata* of the older systematic writers. We presume it to be also the *Campanero* of the Spaniards, called *dara* by the Indians, and bell-bird by the English. "It is about the size of a jay," says Waterton. "His plumage is white as snow. On his forehead rises a spiral tube nearly three inches long. It is jet black, clothed all over with small white feathers. It has a communication with the palate, and when filled with air looks like a spire; when empty, it becomes pendulous. His note is loud and clear, like the sound of a bell, and may be heard at the distance of three miles. In the midst of these extensive wilds, generally on the top of an aged mora, almost out of gun reach, you will see the campanero. No sound or song from any of the winged inhabitants of the forest, not even the clearly pronounced 'Whip-poor-will,' from the goat-sucker, causes such astonishment as the toll of the campanero. With many of the feathered race, he pays the common tribute of a morning and an evening song; and even when the meridian sun has shut in silence the mouths of almost the whole of animated nature, the campanero still cheers the forest. You hear his toll, and then a pause for a minute; then another toll, and then a pause again; and then a toll, and again a pause. Then he is silent for six or eight minutes, and then another toll, and so on. Actæon would stop in mid chase, Maria would defer her evening song, and Orpheus himself would drop his lute, to listen to him, so sweet, so novel, and romantic is the toll of the beautiful snow-white campanero. He is never seen to feed with the other Cotingas, nor is it known in what part of Guiana he makes his nest."[2] In a third species (*Amp. variegata*, Gmel. *Pl. Col.* 51, Plate VI., figure 10) the front of the throat is all beset with numerous fleshy worm-shaped appendages. All these birds are vaguely said to feed upon insects, but on no authority that we can find. "Could we but know," says Mr Swainson, "the habits and economy of these singular birds, which, had they not been seen, might be thought fabulous, what an interesting page of nature's volume would be unfolded! Yet at present we only know that they live in the deepest and most secluded forests of tropical America, where they subsist upon an infinite variety of fruits unknown to Europeans. They are much oftener heard than seen, since their notes are particularly loud, and are ut-

[1] *Ornithological Biography*, vol. i. p. 227.

[2] *Wanderings in South America*, p. 121.

Insessores. tered morning and evening from the deepest recesses of the forests. We have sometimes caught a distant view of them, perched upon the topmost branches of the loftiest trees."[1]

In the genus PROCNIAS (now more restricted than by Hoffmansegg) the bill is likewise very broad, and deeply cleft, but the structure is firmer, and the upper mandible more convex. The nostrils are basal. Example, *P. ventralis*, Illiger, *Pl. Col.* 5.

In the not very closely allied genus CEBLEPYRIS, Cuv. which Mr Swainson classes as the most aberrant division of the shrikes, the bill resembles that of the Cotingas, but the shafts of the rump-feathers are sharp pointed. These birds inhabit chiefly Africa, and prey on caterpillars. Example, *C. phœnicopterus*, Temm. *Pl. Col.* 71.

The genus GYMNODERA, Geoff. (which forms a portion of the *Coracinæ* of Vieillot), has the bill stronger than in any of the preceding *Ampelidæ*, the neck is partially bare, and the head covered with velvety feathers. There does not seem to be more than one species (*G. nudicollis*), described by Shaw under the name of bare-necked grakle. It was classed by Gmelin and Latham as a crow,—the *Corvus nudus* of their respective works.

The Drongos (genus EDOLIUS, Cuv.) have the bill partially depressed and notched, and its upper ridge sharp; but it is distinguished by both mandibles being slightly arched through their whole extent, and the nostrils are covered with feathers. The species are rather numerous, and are characteristic of the tropical countries of the East. The Malabar shrike of Shaw (*Edolius remifer*, Temm. see Plate VI., figure 7), affords a good example. The position of this genus ought certainly to be in closer approximation to the *Laniadæ* than it is in the arrangement of Baron Cuvier. Their habits are insectivorous, and some of the species are said to warble as sweetly as the nightingale. They usually dwell together in society, pursue bees with great avidity, and are often seen to combine in large groups on the outskirts of the forests during morning and evening. The species we have figured is a native of Java and Sumatra.

In the genus PHIBALURA of Vieil. the ridge of the bill is arched, as in Edolius, but shorter, broad at the base, somewhat dilated laterally, and slightly notched. The only known species is a beautiful South American bird (*Ph. flavirostris*, Vieil.; *Ph. cristata*, Swain., *Zool. Illust.* pl. xxxi.), which appears to occur chiefly in the mining districts of Brazil. It was very rare some years back, but has now become comparatively common in collections, in consequence of recent importations.

We come now to an extensive group, the ancient Tanagers, genus TANAGRA of Linn., which, like most of the other genera, has in recent times been numerously subdivided. The bill is convex, sub-triangular at the base, the upper mandible slightly arched, curved at the point, notched, the margins flexuous and enlarged; the nasal fossæ are deep and large, and closed by a membrane; the nostrils are rounded. The wings are rather short. The Tanagers are characteristic of America. They feed both on grain and insects, and are remarkable for the beauty and brilliancy of their plumage. The following are the principal subdivisions. In EUPHONIA, Desm. (*Tangaras bouvreuils*, Cuv.), the bill is short, and exhibits, when viewed vertically, an enlargement at the base on either side. The tail is also short in proportion. Examples,—*Tan. violacea*, Lath.,—*Pipra musica*, Gmel.,—*Tan. diademata*, Pl. Col. 243,—and *Tan. chlorotica*, Gmel. (See Plate VI., figure 9.) In the genus SALTATOR, Vieil. (*Tangaras grosbec*, Cuv.), the bill is conical, thick, inflated, as broad as high, the culmen rounded. Such are *Tan. magna, atra, flammiceps*, &c. In the restricted genus TANAGER (properly so called) the bill is short, though longer than in *Euphonia*, as broad as high, slightly compressed. Examples, *T. tricolor, thoracica, auricapilla*, &c. In the genus TACHYPHONUS, Vieil. (*Tangaras loriots*, Cuv.), the bill is more lengthened, conical, compressed, arched, sharp pointed. Examples, *T. cristata, nigerrima*, &c. In the genus PYRANGA, Vieil. (*Tangaras cardinals*, Cuv.), the bill is strong, lengthened, the point but slightly curved, the margin of the upper mandible often strongly toothed. The wings are rather long. The habits of several of the species of this genus are better known than those of the preceding, in consequence of their more hardy constitution, which enables them to spend the summer months in North America. One of the most beautiful of these is the scarlet tanager (*Tanagra rubra*, Linn.). Among all the birds that inhabit the woods of the United States, there is none, according to Wilson, that strikes the eye of a stranger, or even of a native, with so much brilliancy as this. Seen among the green leaves, with the light falling strongly on his plumage, he appears most beautiful. His whole plumage, with the exception of the wings and tail, is of the most vivid carmine red. The wing-coverts, posterior secondaries, and middle tail-feathers, are black, and form a rich contrast to the other portions of the plumage. After the autumnal moult the male becomes dappled with greenish yellow. The colour of the female is green above and yellow below; her wings and tail are brownish-black, edged with green. Though this lovely species sometimes builds in orchards, and visits cherry trees for the sake of their fruit, it does not frequently approach the habitations of man, but prefers the solitude of the umbrageous woods, where, in addition to fruits, its food consists of wasps, hornets, and humble-bees. The scarlet tanager comes just within the limits of the fur-countries, but is unknown as yet beyond the forty-ninth degree. His nest, placed upon the horizontal branch of a tree, is built of broken flax and dry grass, so thinly woven that the light is easily seen through it. The eggs are only three in number, of a dull blue, spotted with brown; but the bird is supposed to breed more than once a year. The genus Pyranga contains also *Tan. æstiva* and other species.

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We conclude our notice of the Tanagers by a brief indication of the genus RAMPHOCELES, Vieil., of which the bill is strong, compressed, with the sides of the lower mandible so enlarged as to spread backwards towards the cheek. Such is *Tanagra Jacapa* of Gmelin, a South American species, represented in Plate VII., fig. 2.

Our next group consists of birds more or less allied to thrushes. In all, the bill is compressed and arched, but the upper mandible is but slightly hooked, and the notching feeble. As in other extensive assemblages of species, however, the structure is considerably varied. The natural regimen is mingled, consisting both of wild fruits, worms, and insects. A few species are gregarious, the majority solitary. Of ten or twelve kinds which inhabit Europe, we have six in Britain, viz. the missel-thrush (*T. viscivorus*), the song-thrush (*T. musicus*), the field-fare (*T. pilaris*), the red-wing (*T. iliacus*), the blackbird (*T. merula*), and the ring-ouzel (*T. torquatus*). The aspect and general habits of most of these are too familiar to require illustration. The blackbird and the thrush are two of our most delightful and accustomed songsters.

> When snow-drops die, and the green primrose leaves
> Announce the coming flower, the merle's note
> Mellifluous, rich, deep-toned, fills all the vale,
> And charms the ravished ear. The hawthorn bush,
> New budded, is his perch; there the gray dawn

[1] *Natural History and Classification of Birds*, vol. ii. p. 75.

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He hails, and there, with parting light, concludes
His melody. There, when the buds begin
To break, he lays the fibrous roots, and see
His jetty breast embrowned; the rounded clay
His jetty breast has soiled: but now complete,
His partner and his helper in the work,
Happy assumes possession of her home:
While he upon a neighbouring tree his lay,
More richly full, melodiously renews.

.....The thrush's song
Is varied as his plumes; and as his plumes
Blend beauteous, each with each, so run his notes,
Smoothly, with many a happy rise and fall.
Sometimes below the never-fading leaves
Of ivy close, that overtwisting binds
Some riven rock, or nodding castle wall,
Securely there the dam sits all day long;
While from the adverse bank, on topmost shoot
Of odour-breathing birch, her mate's blythe chaunt
Cheers her pent hours, and makes the wild woods ring [1]

The missel-thrush is the largest and strongest of the genus, at least in Europe. He is a bold, pugnacious bird, guarding his nest with great success from the intrusive magpie. His song is loud and clear, but monotonous; something like an ineffectual attempt to combine the tones of the thrush and blackbird. Yet Colonel Montagu admired it greatly. The ring-ouzel affects mountainous and barren places. The field-fare and red-wing are only seen with us in winter, and are known to breed in the more northern parts of Europe. The former sings well, and we have somewhere seen it called the nightingale of Norway.

One of the most noted of the foreign species of the genus is the mocking-bird of America, *T. polyglottus*, Linn. It measures about nine inches in length, is cinereous above, whitish below, with the tips of the wing-coverts, the base of the primaries, and the lateral tail-feathers white. This unrivalled Orpheus and great natural wonder of the American forests inhabits the whole northern continent from the state of Rhode Island to the larger islands of the West Indies, and, continuing through the equatorial regions, is found as far south as Brazil. Neither is it confined to the eastern or Atlantic states, being known to exist in the wild territory of the Arkansa, more than a thousand miles from the mouth of Red River. It breeds around the far western sources of the Platte, near the very base of the Rocky Mountains; and Mr Bullock observed it on the table-land of Mexico. The mocking-bird may be regarded as a permanent (we mean stationary) inhabitant of the milder regions of the western world, though such as are bred to the north of the Delaware seem to move southwards before the approach of winter.[2] The period of incubation varies with the latitude. A solitary thorn, an almost impenetrable thicket, an orange tree, cedar, or holly bush, are favourite places; and during this important period neither man nor beast can approach without being attacked. Cats are especially persecuted; yet his chief and most vengeful rage is directed against the black snake, a mortal enemy. The male bird darts upon the insidious reptile with the greatest courage, and by violent and incessant blows upon the head, sometimes deprives him of life. The boasted fascination of his race, his lurid eye, his sharp envenomed fangs, avail not when competing with the love of offspring, that pure and beautiful affection, the least selfish of all instinctive feelings. "The plumage of the mocking-bird," says the first great historian of the American feathered tribes, "though none of the homeliest, has nothing gaudy or brilliant in it; and had he nothing else to recommend him, would scarcely entitle him to notice; but his figure is well proportioned, and even handsome. The ease, elegance, and rapidity of his movements, the animation of his eye, and the intelligence he displays in listening and laying up lessons, from almost every species of the feathered creation within his hearing, are really surprising, and mark the peculiarity of his genius. To these qualities we may add that of a voice full, strong, and musical, and capable of almost every modulation, from the clear mellow tones of the wood-thrush to the savage scream of the bald eagle. In measure and accent he faithfully follows his originals. In force and sweetness of expression he greatly improves upon them. In his native groves, mounted on the top of a tall bush or half-grown tree, in the dawn of dewy morning, while the woods are already vocal with a multitude of warblers, his admirable song rises pre-eminent over every competitor. The ear can listen to his music alone, to which that of all the others seems a mere accompaniment. Neither is this strain altogether imitative. His own native notes, which are easily distinguishable by such as are well acquainted with those of our various song birds, are bold and full, and varied seemingly beyond all limits. While thus exerting himself, a bystander, destitute of sight, would suppose that the whole feathered tribes had assembled together on a trial of skill, each trying to produce his utmost efforts, so perfect are his imitations. He many times deceives the sportsman, and sends him in search of birds that perhaps are not within miles of him, but whose notes he exactly imitates; even birds themselves are frequently imposed on by this admirable mimic, and are decoyed by the fancied calls of their mates, or dive with precipitation into the depth of thickets, at the scream of what they suppose to be the sparrowhawk."[3]

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The mocking-bird sometimes breeds in captivity. Many years ago a Mr Klein, of Philadelphia, partitioned off a space of twelve feet square within doors, lighted by a pretty large wire-grated window. In the centre he placed a cedar-bush, five or six feet high, in a box of earth, and scattered about a sufficient quantity of materials suitable for building. A male and female mocking-bird were introduced, and soon began to build. When the nest was completed the female laid five eggs, all of which she hatched, and she fed the young with great affection till they were nearly able to fly. Business, unfortunately, called the proprietor from home for a fortnight, and the care of the colony being left to the domestics, the result may be anticipated. On his return the young were utterly dead, and the parents nearly famished.

Several African species allied to our present group dwell together like starlings, in numerous chattering flocks, pursuing insects, and committing great depredations in gardens. Several are remarkable for the lustrous splendour of their plumage. Such are *Turdus auratus* and *nitens* of Gmelin. The Senegal species, called the glossy thrush, *T. æneus*, is characterized by the magnificent length of its caudal plumes. These richly attired species belong to the genus LAMPROTORNIS, Temm. Other species, in which the bill is slender and lengthened (as in the Brazilian thrush of Lath.), form the genus Ixos of the last-named author; while the genus ENICURUS (more nearly related, however, to the fly-catchers) consists of one or two species with a stronger bill, the tail long and forked. Such is *E. coronatus*, Temm. *Pl. Col.* 113; and *E. velatus*, ibid. 160, from Java. GRALLINA of Vieillot is constituted by a New Holland species with a straight, lengthened, rather rounded bill, and long legs. The plumage is black and white. Ex. *G. melanoleuca*, Vieil. The genus TRICHOPHORUS, Temm. is composed of species of which the bill is very strong, and garnished at the base with long, projecting bristles, which sometimes prevail also on the

[1] Grahame's *Birds of Scotland.* [2] Nuttall's *American Ornithology*, i. 321. [3] Wilson's *American Ornithology*, ii. 92.

Insessores. occiput. The manners of these birds are as yet unknown. They live in Western Africa. Ex. *Tr. barbatus*, Temm. *Pl. Col.* 88.

The ant-thrushes, MYOTHERA, Illiger, come next in order. They are chiefly distinguished by their long, slender tarsi, and short tails. (See Plate VII., figure 1.) The species of the ancient world, inhabitants for the most part of India, the eastern islands, and New Holland, are characterized by brilliant and contrasted colouring. These are the *Breves* of Buffon, the short-tailed crows of English writers. They form the genus PITTA of Vieillot and Temm., of which the bill is strong but thrush-like (*P. cyanurus, brachyurus*, &c.); while MYOTHERA, as now restricted, contains the American species, of much more sober plumage, with the bill more abruptly hooked, and the tooth stronger. The species dwell among the enormous ant-hills of the western world, keeping much upon the ground. They seldom fly, and certain kinds are remarkable for their deep sonorous voices. The largest, longest legged, and most singular in its general aspect, known under various names, such as long-legged crow, king-thrush, &c. (*Corvus grallarius*, Shaw; *Turdus rex*, Linn.), constitutes the genus GRALLARIA of the modern systems. It is a native of Guiana. The beautiful New Holland bird, with a bill like a thrush, but shorter, the legs long, the nails almost straight, and the lengthened tail-feathers terminated by sharp points, forms the genus ORTHONYX, and is placed by Cuvier immediately after the preceding group of ant-eating thrushes.

The genus CINCLUS, Bechstein, characterized by an almost straight, compressed, sharp-pointed bill, comprises our well-known water-ouzel, *C. aquaticus*. This interesting bird is frequent along the banks of rivers, but seems to prefer those of a somewhat rocky, alpine character. It lives in pairs, keeping always close by the stony margin of its chosen stream. The nest, according to Sir William Jardine, is formed exactly like that of our common wren, with a single entrance, and is composed of ordinary mosses, without much lining. It is usually placed beneath some projecting rock, not many yards above the water, "and often where a fall rushes over, in which situation the parent birds must dash through it to gain the nest, which they do with apparent facility, and even seem to enjoy it. At night they roost in similar situations, perched with the head under the wing, on some little projection, often so much leaning as to appear hanging with the back downwards. I recollect a bridge over a rapid stream, which used to be a favourite nightly retreat, under an arch; I have there seen four at a time sitting asleep in this manner, and used to take them with a light. Before settling for their nightly rest, they would sport in the pool beneath, chasing each other with their shrill and rapid cry, and at last suddenly mount to their perch; when disturbed, they return again in five minutes."[1] During winter they migrate to the lower streams; but in summer are most abundant on the alpine tributaries. They feed on small fish and insects, and are remarkable for their power of walking, with the assistance of their wings, beneath the surface. There is an American species (*C. Americanus*), of somewhat larger size, and of a uniform brownish slate colour. It extends along the range of the Rocky Mountains, from Mexico to Lake Athabasca. There is also an Asiatic species, figured by Mr Gould,[2] under the title of *C. Pallasii*, a name formerly bestowed on a bird supposed to come from the Crimea.

Mr Brehm has described another species by the name of black-bellied water-ouzel (*C. melanogaster*). It inhabits the north-eastern parts of the European continent, visiting in severe winters the coasts of the Baltic, where it is neither shy in its habits, nor distrustful of the presence of man. We are rather inclined, however, to distrust some of Mr Brehm's species. Insessores.

The genus PHILEDON of Cuvier has the bill slightly arched throughout its whole length, compressed, broadened at the base; the nostrils are large, protected by a cartilaginous scale, and the tongue terminates in a sort of tuft. Hence the species are by many classed among the honey-sucking or tenuirostral tribes. Many of them are remarkable for some particular garniture about the base of the bill, and are found in New Holland and the eastern islands. The genus is very extensive, but not very naturally composed, as it consists of species brought from a variety of other genera, such as *Certhia, Merops, Gracula, Sturnus*, &c. Some have a fleshy wattle depending from the lower mandible, as in *Phil. carunculatus* of New Holland (which forms the genus CREADON of Vieillot). In others the head is partially bare of feathers, as in the *goruk*, likewise a native of New Holland, a bold and restless bird, which feeds both on insects and honey, and often puts to flight whole droves of blue-bellied parrakeets. Some have neither bare skin nor wattles, but are distinguished by a peculiar frizzled character of parts of the plumage. The poe bee-eater of Cook's voyage (*Phil. Cincinnatus*) is of this kind. It is a beautiful bird, of a glossy blackish green, with a band of white across the upper portion of the wing, and a pendent tuft of long, twisted, white feathers on each side of the neck. It is a native of New Zealand, and was formerly in great request, as contributing to ornament the feathered mantles worn by chiefs and persons of distinction. The species is also said to sing well, and is moreover highly esteemed as an article of food.

In the genus EULABES, Cuv. (*Mainatus*, Brisson; *Gracula*, Vieil.), the bill is strong, compressed, high, the culmen arched, the sides dilated towards the gape. A portion of the cheek is bare, and a fleshy appendage stretches towards the occiput from either eye. Here are placed the famous mina birds, of which two species seem to have been confounded by Linnæus under the title of *Gracula religiosa*. The specific name was first applied by misapprehension, in consequence of a Musulman woman refusing, on account of some religious scruple, to allow a European artist to make a drawing of one of these birds, which she had in captivity. Some uncertainty seems still to pervade the naming of the species. The Indian kind (*G. Indicus*, Cuv.) is somewhat larger than a blackbird, the plumage of a fine silky black, with a white spot upon the central edge of the wings, the bill and feet yellow. This bird is easily tamed, and becomes extremely familiar in confinement. It is probably the most accomplished linguist of all the feathered tribes, and may be taught to pronounce long sentences in the most clear and articulate manner. It is consequently held in high esteem, and is frequently brought alive to European countries, although it must be confessed that the purity of the English tongue is not always exhibited by the result of its maritime education. The food of the mina in a state of nature is said to consist both of fruits and insects. It greatly loves bananas, and in this country has no objection to either grapes or cherries. The larger species *G. Javanus*, Cuv.) equals the size of a jay. (See Plate VII., figure 3.) The bill is broader, more hooked at the end, but without the notch. Now M. Lesson gives the name of *Sumatranus* to this species, and

[1] Note to Wilson and Bonaparte's *American Ornithology*, vol. iii. p. 451.

[2] *Century of Birds from the Himalaya Mountains.*

Insessores. says that the Javanese, who esteem it highly, and part with it unwillingly, obtain it only by navigation. The Indian species he has named *Javanus*, but without assigning any special reason for such transmutations. The plumage is the same in both. Old Edwards seems long ago to have indicated the two kinds. "The greater minor," says he, "for bigness equals a jackdaw or magpie; the lesser hardly exceeds a blackbird, so that the one is at least twice as big as the other." The bird described by Bontius as an Indian starling was a mina. It imitated man's voice more accurately than a parrot, and "was oftentimes troublesome with its prattle."

In the genus GRACULA, Cuv. (*Pastor*, Temm.), the bill is compressed, straight, or but slightly arched, the notch feeble, and the commissures form an angle as in the starlings. This restricted genus contains several interesting species, such as the pagoda-thrush (*G. pagodarum*), so called from its frequent occurrence among the pagodas of Malabar and Coromandel. According to Sonnerat, it is often kept caged for the sake of its song. The paradise grakle of Latham (*Par. tristis*, Linn.) also pertains to this genus. It is well named *Gracula gryllivora* by Daudin, and is remarkable, as its name implies, for the destruction of locusts. We abridge the following particulars from Buffon. The island of Bourbon, where this species was formerly unknown, was once overrun to an alarming extent by locusts, which had been accidentally introduced from Madagascar. The governor-general and the intendant of the island, alarmed at the desolation which was taking place, deliberated on the best means of extirpation, and with that view they introduced several pairs of the so-called paradise grakle from India. The plan promised to be successful; but unfortunately some of the colonists observing the birds eagerly thrusting their bills into the soil of the newly-sown fields, imagined they were in quest of grain, and spread a report that the grakles, so far from proving beneficial, were likely to be highly detrimental to the country. The case was argued in due form. It was stated on the part of the grakles, that they ransacked the new-ploughed fields, not for grain, but insects; but the opposite view prevailed, and two hours after the edict of proscription passed, not a living individual was to be found in the island. A speedy repentance followed this intemperate and hasty execution, the locusts regained their ascendency, and soon becoming more injurious than ever, the grakles were again introduced, after an absence of nearly eight years. Their preservation and extension now became an affair of state, laws were enacted in their favour, and the physicians (we presume, from policy) declared their flesh unwholesome. An opposite inconvenience, however, is said to have since arisen. The birds having prodigiously increased in numbers, and being no longer adequately sustained by insect food, have had recourse to grapes, dates, and mulberries, and have even proceeded to scratch up rice, maize, wheat, beans, and other useful produce; they enter pigeon-houses, and attack both eggs and young; and thus, after destroying the destroyer, they have themselves become a greater pestilence than that which they extirpated. There is perhaps some exaggeration in the concluding parts of this statement, as M. Duplessin, who resided several years in the island, states that the laws for its preservation are still in force. We may add, that this bird is of the same lively and imitative disposition as the mina, and is easily taught to speak. When kept near a farm-yard, or other place resorted to by different kinds of creatures, it spontaneously acquires the various cries of dogs, ducks, geese, sheep, pigs, and poultry. The manners of the genus in general resemble those of the starling. They fly in troops, searching for insect prey; their habits are familiar, their docility remarkable, and their Insessores. powers of imitation almost unparalleled. The only European species hitherto classed with the grakles is the beautiful rose-coloured ouzel (*P. roseus*), which occurs in several of the warmer countries of Asia and Africa, is not unfrequent in Spain and Italy, and shows itself in other parts of Europe, more rarely as we proceed northwards. Even in Tuscany and the Lombardo-Venetian territory it is esteemed unusual. A few are recorded to have built their nests in the Florentine district in 1739. We do not know that they have been since observed to breed in Europe. They were very common in Dalmatia in 1832; and in the year following one was shot in Ross-shire.

In the genus PYRRHOCORAX, Cuv. the bill is compressed, arched, rather slender, slightly notched, the nostrils covered with feathers. We have two European species, according to Temminck's views, viz. the alpine crow of Latham (*P. pyrrhocorax*), and our own red-legged crow (*P. graculus*). The former inhabits the highest of the Northern and Helvetian Alps, seldom showing itself during the summer season at any distance from the regions of perpetual snow; the latter is also mountainous, but more widely spread over countries of less elevation. It is not unfrequent along many of the rocky coasts of England and Wales, is frequent in the Isle of Man, and occurs occasionally along the western shores of Scotland, and in Colonsay and other islands. Baron Cuvier places this bird alongside the hoopoes, as a tenuirostral genus called FREGILUS.

In the genus ORIOLUS the bill resembles that of the thrushes, but is more powerful. The legs are shorter, and the wings rather more lengthened. As now restricted, this genus contains only the species of the ancient continent, those of America (*Icterus, Cassicus*, &c.) being included among the conirostral tribes. The golden oriole (*Oriolus galbula*) is one of the most beautiful of European birds. It occurs occasionally in Britain. It breeds in many parts of the European continent, arriving in spring and departing in autumn. It builds on the tops of trees, its nest being attached to and partly suspended from a forked branch. This species feeds on fruits and insects, and is particularly fond of figs. The Italian peasants suppose its cry to signify "Contadino, é maturo lo fico?" Its own flesh is of most excellent flavour, especially in autumn, when having for a time fared sumptuously on the best of fruits, it has become extremely fat. The rich plumaged regent bird of New South Wales (*Sericulus chrysocephalus*, Swainson) is by some regarded as an oriole.

The genus GYMNOPS, Cuv. possesses the strong bill of the orioles, but a great part of the head is bare of feathers. In some of the species there is a prominence on the base of the beak. Such are the knob-fronted bee-eater of White[1] (*Merops corniculatus*), figured by Vaillant under the name of corbicalao (*Ois. d'Amérique et des Indes*, pl. 24), and the cowled bee-eater (*Merops monachus*, Latham). The tongue is said to be tufted like that of *Philedon*. To the genus Gymnops Cuvier also refers the bald grakle (*G. calva*, Linn. and Lath.), a remarkable species, native to the Philippine Islands, where it is said to build in the hollows of the cocoa-nut tree. It feeds on fruits, and is extremely voracious.

In the genus MENURA, Shaw, the bill is straight, somewhat triangular at the base, compressed, the nostrils lengthened, central. Region of the eyes bare. Feet large and strong. The only known species of this singular and somewhat anomalous genus, the lyre-tail of New Holland (*M. lyra* or *superba*), is characterized by the great extension and peculiar structure of the tail-feathers. (See Plate VII., figure 4.) It is equal in size to a pheasant.

[1] *Voyage to Botany Bay*, p. 190.

Insessores. The general plumage is brown. The tail of the female is of the ordinary structure. This bird inhabits rocky districts. Though placed in its present station by Cuvier, it certainly seems more allied to the gallinaceous than the passerine order. Its history, however, is still obscure, and its anatomical structure, we believe, has not yet been investigated.

From the last-named genus, it would appear an abrupt and bold transition to the feeble-bodied, soft-billed stone-chats, warblers, wagtails, and other *Sylviadæ*, all of which, however, Baron Cuvier has here grouped as intermediate between *Menura* and *Pipra*. They form a very numerous assemblage, all characterized by a rather straight and slender bill, but varying, on the one hand, by the depression of the mandibles, towards the fly-catchers, and on the other, by its compression and curvature, towards the straight-billed butcher-birds. The Sylviadæ or warblers are divided by Mr Swainson into the five following sub-families, viz. 1st, *Saxicolinæ* or stone-chats, in which the bill is depressed at the base, the gape furnished with diverging bristles, the feet lengthened, the tail rather short, the head large; 2d, *Philomelinæ* or nightingales, in which the general structure is larger and more robust than in the typical warblers, and the feet more formed for perching; 3d, *Sylvianæ* or true warblers, of which the size is very small, the structure weak, the bill very slender, straight, with the under mandible much thinner than the upper; 4th, *Parianæ* or tit-mice (placed by Cuvier in the conirostral tribe), in which the bill is either entire or very slightly notched, and more or less conic, the hind toe large and strong, and the lateral toes unequal; 5th, *Motacillinæ* or wagtails, in which the bill is lengthened, straight, and slender, the legs long, and formed for walking, the hind toe elongated, and the tail narrow and lengthened.[1] Mr Swainson has elsewhere remarked, that the Sylviadæ might be termed "ambulating fly-catchers," since, when viewed collectively, they are only separated from the *Muscicapinæ* by a different mode of feeding, indicated by the superior length and structure of their feet,—these parts being adapted for constant locomotion, either among branches or upon the ground; while in the true fly-catchers the feet are short, small, and feeble, in accordance with the sedentary habits of the species. "Comparing the warblers, on the other hand, with the thrushes, we see that the best distinction between the two groups lies in the very character which assimilates the *Sylviadæ* to the fly-catchers, namely, the basal depression of the bill. We allude, of course, to typical examples; since all these distinctions are softened down, in proportion as the three groups approximate.[2] We shall now proceed with our exposition of Baron Cuvier's system.

The genus Saxicola, Bechstein, has the bill slightly depressed and broadened at the base. The species of this genus seem confined to the ancient continents and New Holland. They feed on insects, build on the ground or among heaps of stones, and usually frequent rather wild and barren places. We have three British species, the wheat-ear or white-rump (*S. œnanthe*), which is migratory, and arrives with us in early spring, frequenting commons and mountain pastures, but also occurring in more cultivated places, though always preferring open districts; the whin-chat (*S. rubetra*), likewise migratory, but later in its arrival, and frequenting moorlands and commons covered with furze or low brushwood, where it is almost always seen to alight upon the topmost spray; and the stone-chat (*S. rubicola*), which resides in Britain throughout the year, and is often found in moistish places. Of these the white-rump is the most esteemed as food, being compared by many to the ortolan. It is much sought after in Italy, that "land of song," where, by the strangest mal-association, a man no sooner hears a feathered warbler sing than he desires to shoot and eat it. Even in the southern parts of Britain it is much esteemed; and Pennant tells us, that as many as 1840 dozen have been taken in a single season at East Bourne, in Essex. In the south of Europe it is usually captured by means of a peculiar net, and the lure of a living owl; with us a noose of horse-hair placed between two upraised or inclined portions of turf, between which the bird attempts to pass in search of insects, is found sufficient. In regard to the stone-chat, Temminck mentions that, though stationary in Africa, in Europe they are birds of passage. It is singular in this case that they should remain throughout the year in Britain. The fact that they do so, however, is undoubted, as we have ourselves shot them on the Pentland Hills when the ground was covered with snow. Signor Savi mentions that they are stationary in Tuscany, although "per il tempo del caldo maggiore dell' estate, e dell autunno, molti abbandonano le pianure, e si retirano sù i monti per cercare luoghi più freschi."[3] Insessores.

In the genus Sylvia of Wolf and Meyer (*Ficedula*, Bech.) the bill is merely a little narrower at the base than in the preceding. The generic title, however, has been variously applied of late, by different writers, to their restricted groups,—Mr Selby using it to designate our willow and wood wrens, while Cuvier makes it contain, among others, the four following British species, viz. the red-breast (*S. rubecula*), the blue-throat (*S. suecica*), the common red-start (*S. phœnicurus*), and the black red-start (*S. tithys*). Of these, the second and fourth can scarcely be regarded as otherwise than of accidental occurrence in England, and have never been seen in the northern quarters of the island. The red-breast is perhaps the most beloved of British birds, and is remarkable for its combination of familiarity and independence. When left to its "own sweet will," it enters houses freely in cold or snowy weather, will perch night after night on corniced book-case, or seek repose upon the golden scallop of a picture frame; but it hates all forwardness in others, and will not voluntarily come in contact with any hand, however beautiful. It hops delighted, singing as it goes with low and plaintive note, along the comfortable carpet, or darting up suddenly towards the window-frame, will utter a louder gush of angrier melody on seeing some orange-breasted brother, perched on leafless spray, still braving the increasing darkness. For a time, just before nightfall, he seems himself to suffer from some uneasy instinct, or probably desires, from habit, to secure his usual perch in old fantastic yew or thick screened holly; but, on second thoughts, he soon assumes some quiet corner, above the reach of curious children's hands. Not seldom when the evening fire burns brightest, he descends on muffled wing, his large and liquid eye dilated less with fear than quiet wonder, and after a brief survey, he re-ascends his place of safety. Although this bird remains about our doors throughout the summer, building near out-houses and in orchards, yet

> Some red-breasts love amid the deepest groves
> Retired to pass the summer days. Their song
> Among the birchen boughs, with sweetest fall
> Is warbled, pausing,—then resumed more sweet,
> More sad, that to an ear grown fanciful,
> The babes, the wood, the men, rise in review,
> And robin still repeats the tragic line.

We have a notion, that in Scotland the female red-breast is migratory. At least, in the vicinity of Edinburgh, we recognise her not throughout the long-enduring winter. All the individuals then about our gardens *sing* and *fight*, till, in the month of March, some strangers show themselves, but do not sing, and are immediately followed and

[1] *Nat. Hist. and Classif. of Birds*, ii. 238. [2] *Fauna Boreali-Americana*, part ii. p. 20. [3] *Ornitologia Toscana*, i. 231.

Insessores. *fed* by the resident males, at which time they (the supposed females) utter a low hissing note, and flutter their wings like young dependent birds. This we have often seen, and vouch for.

The red-start is a rarer species. It haunts retired well-wooded lanes, where the timber is in a better state than the stone dikes; for it highly approves of the latter when old, moss-covered, and full of holes. It is a bird of passage, and although greatly less familiar than the red-breast, we have seen it build beneath the cottage eaves. It is an active, restless bird, easily recognised by its snow-white forehead, black throat, ashy back, and fine reddish orange breast and rump, to say nothing of the constant vibratory motion of the tail.

The blue bird of America (*Sylvia sialis*) has the whole of the upper plumage of a fine blue, while the throat, neck, breast, and flanks, are bright orange brown. In general character and movement this bird resembles the European red-breast, and may be said to be as familiarly known in summer to the children of America as the robin is to ourselves. Wilson informs us that its society is much courted by the inhabitants of the country, and that few farmers neglect to provide for him a snug little summer-house, ready fitted, and rent free. He is migratory over the northern districts, but a few remain throughout the winter in some parts of the United States. A more recently described species, nearly allied to the preceding, was procured by Dr Richardson at Fort Franklin, and is named by Mr Swainson *Erythaca arctica*. Its colour is a fine ultra-marine blue above, beneath greenish blue, whitish on the lower part of the abdomen, and under tail-coverts. It seemed to be merely a summer visitant of the fur-countries, and no other knowledge of its haunts or habits has been yet obtained.

The genus CURRUCA, Bechstein, has the bill straight, slender throughout, a little compressed anteriorly, the upper mandible slightly curved towards the point. It contains that prince of European songsters, the nightingale (*C. luscinia*), a bird of shy and unobtrusive disposition, seldom seen in open places, but loving the protection of a close entangled undergrowth of brakes and bushes. Its powers of song are generally admitted to be unrivalled, although the effect is no doubt enhanced by the solemn stillness of the summer night, when every other voice has sunk to rest,—for then

> The wakeful bird
> Sings darkling, and in shadiest covert hid
> Tunes *her* nocturnal notes.

The words of the divine Milton are sacred; yet we know not that the female sings. It is a curious coincidence, however, that she should be asserted so to do by Pliny. Our British nightingales never venture farther north than Doncaster, although in Sweden and the northern parts of Germany they are less restricted in their summer movements. To this genus belong several other excellent British songsters, such as the rich-voiced black-cap (*C. atricapilla*), the greater petty-chaps (*C. hortensis*), and the white-throat or muggy (*C. cinerea*). These, as well as the following, are called abroad *fauvettes*.

A few species which affect damp underwood and reedy marshes, such as the grasshopper warbler (*S. locustella*), the sedge-warbler (*S. phragmitis*), and the reed-wren (*S. arundinacea*), constitute the genus SALICARIA of Mr Selby. To the same little group, we doubt not, belongs the *beccamoschino* of the Tuscans (*Sylvia cisticola*, Temm.), remarkable as exhibiting the propensities of a tailor-bird. The nest is placed near, but not upon the ground, usually in a bush of lengthened herbage, the leaves and stalks which form the external covering being drawn together, while a flooring for the nest is made somewhat lower down, by curving the leaves across. The beauty of the structure consists in this, that the latter are not supported by their mutual interlacement, but are sewed together, sometimes by spiders' webs, sometimes by thread-like portions of various plants. The interior is chiefly composed of vegetable down. The nests constructed in April are much less finished than those of August, owing to the absence, in the earlier month, of several materials which greatly conduce towards their elegance and solidity.[1] Insessores.

Another limited genus, called ACCENTOR, has the bill also slender, but rather more conical than the other Sylviæ, with the edges slightly bent inwards. The species are much more hardy than the preceding (all of which are birds of passage); and our only British representative, commonly called the hedge-sparrow (*A. modularis*), remains with us throughout the winter. It seems characteristic of the northern parts of Europe, being seldom seen in France except during winter; and the few that occur in Italy are known to breed among the mountains, only descending to the plains when the summer heat is over. With us what school-boy knows not its mossy, twig-entangled nest, and pure unspotted eggs of greenish blue? A larger and still hardier species is the alpine warbler (*A. alpinus*), of the accidental occurrence of which in the garden of King's College, Cambridge, an instance is recorded by Mr Selby. This bird is an inhabitant of the most mountainous regions of Europe, and particularly affects those districts which are of an abrupt and rocky character. It is common among the Alps of Switzerland, and may be usually seen in the environs of the convent of St Bernard. In summer it ascends to a great elevation, where it breeds beneath the ledges of the rocks, laying four or five eggs of a greenish-blue colour. As winter advances, and the snow begins to gather amid the desolate steeps, it descends towards the vales and middle regions of the mountains, where it subsists upon the seeds of alpine grasses, and of other plants. In summer it destroys grasshoppers, and various insects, and their larvæ.[2]

In the genus REGULUS, Cuv., the bill is still slender, but conical, sharp pointed, and the sides, when viewed from above, are slightly concave. The species are much more active and arboreal than those last named. We may mention as an example our beautiful golden-crested wren (*R. auricapillus*, Selby; *Mot. regulus*, Linn.), the smallest of British birds. It inhabits woods and forests, and flits rapidly from tree to tree, examining the leaves and branches in search of insects. Its manners resemble those of the tit-mice, in company with which it often travels. Mr Selby has recorded, that after a severe gale from the north-east, *thousands* of these tiny creatures were seen to arrive upon the sea-shore and sand-banks of the Northumbrian coast,—many of them so fatigued as to be unable to rise again after alighting on the ground. In this genus Cuvier retains our willow or yellow wren, and lesser petty-chaps (*M. trochilus* and *hippolais*), which most other modern writers keep apart in their restricted genus Sylvia, bestowing other titles (*Erythaca, Phœnicura, Philomela*, &c.) on the genus which Cuvier has so called. These transpositions are the bane of Ornithology. Several true Reguli inhabit North America.

Our common (kitty) wren forms, with certain foreign species, the genus TROGLODYTES of Cuv. The bill is rather more slender than in Regulus, and slightly arched.

The generic name of MOTACILLA, of such extensive application in the older systems, is now restricted to the wag-tails, such as *M. alba* and *cinerea*, Linn. Our yellow

[1] *Nuovo Giorn. de' Letterati*, t. vi. (where the nest is figured); and *Ornitologia Toscana*, t. i. p. 282.
[2] *Illustrations of British Ornithology*, vol. i. p. 247.

 species, which differs from the others in being a bird of passage, is moreover distinguished by an arched and lengthened hind claw, and forms the genus BUDYTES, Cuv., founded, perhaps, upon a character of no great importance. All the wag-tails are peculiar to the ancient continent.

The genus ANTHUS, Bechstein, so long united to the true larks, has the bill straight, slender, rather subulate towards the point, the base of the upper mandible carinated, the tip slightly bent, and emarginated. The hind claw is more or less produced. We have three British species, the rock or shore pipit (*A. aquaticus*), the tit-lark or meadow pipit (*A. pratensis*), and the tree pipit (*A. arboreus*). Richard's pipit (*A. Richardi*, Vieil.) may be included in our list of accidental visitants.

The great tribe of *Dentirostres* is terminated by Cuvier with certain groups which differ from all the preceding by the closer union of the outer and middle toes, which are joined together for a considerable space, after the manner of the syndactylous tribes.

Of these groups the first is composed chiefly of the *manakins* (Genus PIPRA, Linn.), in which the bill is short, compressed, higher than broad, notched, the nasal fossæ large, the nostrils concealed by feathers. The tail and legs are short. They may be subdivided as follows.

In the genus RUPICOLA of Brisson the species are of considerable size, and their heads are ornamented by a double crest of vertical feathers. The only species known are South American, and are distinguished by the name of rock manakins. *P. aurantia*, Vieil. (*Pipra rupicola*, Gm.), is of a brilliant orange colour, with peculiar frizzled feathers on the wings and tail. It is one of the most beautiful of birds, lives on fruits, scrapes in the ground like the Gallinæ, and constructs its nest among the deep caverns of the rocks. It is shy and mistrustful, and flies with great rapidity. The female, which is of a brown colour, lays two eggs of the size of those of a pigeon. The immature birds are also brown. This species inhabits the rocks by the rivers of Guiana. Not far from the banks of the river Oyapoc, to the windward of Cayenne, is a mountain which contains an immense cavern. There also, according to Waterton, the cock of the rock is plentiful. He is of a gloomy disposition, retiring during the day among the darkest rocks, and only coming out to feed a little before sunrise and at sunset. The South American Spaniards call him *Gallo del Rio Negro*, supposing that he is only met with in the vicinity of that far inland stream; but he is common in the interior of Demerara, amongst the huge rocks in the forests of Macoushia, and has been shot south of the line, in the captainship of Para. *R. Peruviana* is a nearly allied species, of somewhat larger size, but wanting the frizzled character of the wing and tail feathers. It inhabits Peru. The female is still unknown. Our author here places the beautiful green species from Java and Sumatra (*Calyptomena viridis* of Horsfield), which he thinks differs from the other Rupicolæ chiefly in the crest not being fan-shaped. (See Plate VII., figure 7.) The true manakins (genus PIPRA, Cuv.) are of much smaller size. They likewise inhabit America, where they dwell in the deep and humid forests, feeding, it is said, both on fruits and insects. They are in general distinguished by the rich and varied colouring of their plumage. We have figured as an example a beautiful Brazilian species, the *Pipra pareola*. (See Plate VII., fig. 5.)

The terminal group of the *Dentirostres* is formed by the genus EURYLAIMUS, Horsfield, in which the bill is much stronger and broader than in any of the preceding, being in some of the species so greatly depressed and expanded at the base, as to exceed the breadth of the head. The upper overlaps the under mandible. These birds are peculiar to India and the great eastern islands, and now amount to five or six in number, which, however, offer such disparity in the structure of the bill, as to render subdivision unavoidable. This has been in part effected; the genus CYMBIRHYNCHUS, Vigors, containing *Eu. nasutus*, while the specific name of another (*Eu. corydon*), remarkable for the extraordinary expansion of the upper mandible, is used generically by M. Lesson, the species itself being termed *Temminckii*. (See Plate VII., figure 8.) We know little of the manners of any of these birds. When actually ascertained, they may probably be found to offer a considerable disresemblance. They have hitherto been generally found in wild and desert places, by the banks of rivers, and are supposed to feed both on fruits and insects,—a frequent, if not a safe conclusion on the part of naturalists, regarding almost every unknown species which happens to be neither a goose nor an eagle.

TRIBE 2D.—FISSIROSTRES.

This restricted tribe consists of the swallows, swifts, and goat-suckers, and is characterized by the bill being short, broad, depressed, slightly curved, without any tooth, and so deeply cleft as to give peculiar wideness to the gape,—a structure of great use to birds which prey so exclusively on insects taken on the wing. Their insectivorous regimen induces migratorial habits, and all the species leave ourselves and other northern nations so soon as the sear and yellow leaves of autumn betoken the approach of frost, and the consequent decrease or extirpation of insect life. Like the raptorial order, or birds of prey properly so called, the fissirostral tribe is capable of a binary division into diurnal and nocturnal species.

Swallows, in general (HIRUNDO, Linn.), are remarkable for their close-set, usually glossy plumage, the great length of their wings, their swift, powerful, easy, and long-continued flight. They occur in almost every region of the globe. In the restricted genus HIRUNDO, Cuv., the toes are disposed as in the majority of birds, that is, three anterior and one posterior. In some of the species the legs and feet are clothed with feathers, the hind claw is slightly disposed to turn forwards, the tail is forked, and of medium size. Such is our martin or window-swallow (*H. urbica*) which forms so cheerful a feature in many of our villages and country dwellings, building beneath the eaves of houses, or the upper angles of windows. It is glossy bluish-black above, the rump and all the lower regions white. In others the legs and feet are naked, the tail forked, and of great length. Such is our chimney-swallow (*H. rustica*), which usually builds in out-houses, and leaves the top of its nest uncovered. Its upper parts, and the higher portion of the breast, are black; the forehead and throat deep orange-brown, the lower portions of the body white. This species usually appears a few days earlier in April than the preceding. Although the migratory movements of both these birds may be still regarded as mysterious, there is now no doubt of the fact that they do migrate. It appears from the observations of M. Natterer, that they moult in February, that is, during their absence from this, the land of their nativity,—a fact which would of itself suffice to overthrow the idea of their long-protracted winter sleep. It is also in respect to other purposes as usual well ordained, for if the heavy moult which befalls so many species during spring or autumn, were equally to affect these long-winged birds, their flight from foreign lands, or journey thither, might be procrastinated, or prevented altogether. Swallows are probably the most purely and exclusively insectivorous of all birds, and even if they could themselves withstand our winter's cold, they would soon perish miserably from want of food.

This extreme sensibility of course renders it difficult to keep swallows caged, or otherwise confined, throughout the winter season. Yet several instances are known

Insessores. of their surviving that inclement period. The following is given by Mr Bewick, on the authority of the late Sir John Trevelyan. The experiments were made by a Mr Pearson. "Five or six of these birds were taken about the latter end of August 1784, in a bat-fowling net, at night; they were put separately into small cages, and fed with nightingale's food. In about a week or ten days they took the food of themselves: they were then put altogether into a deep cage, four feet long, with gravel at the bottom; a broad shallow pan with water was placed in it, in which they sometimes washed themselves, and seemed much strengthened by it. One day Mr Pearson observed that they went into the water with unusual eagerness, hurrying in and out again repeatedly with such swiftness as if they had been suddenly seized with a frenzy. Being anxious to see the result, he left them to themselves about half an hour, and on going to the cage again found them all huddled together in a corner apparently dead; the cage was then placed at a proper distance from the fire, when two of them only recovered, and were as healthy as before—the rest died; the two remaining ones were allowed to wash themselves occasionally for a short time only; but their feet soon after became swelled and inflamed, which was attributed to their perching, and they died about Christmas. Thus the first year's experiments were in some measure lost. Not discouraged by the failure of this, Mr Pearson determined to make a second trial the succeeding year, from a strong desire of being convinced of the truth respecting their going into a state of torpidity. Accordingly, the next season having taken some more birds, he put them into the cage, and in every respect pursued the same methods as with the last; but to guard their feet from the bad effects of the damp and cold, he covered the perches with flannel, and had the pleasure to observe that the birds throve extremely well. They sang their song through the winter, and soon after Christmas began to moult, which they got through without any difficulty, and lived three or four years, regularly moulting every year at the usual time. On the renewal of their feathers, it appeared that their tails were forked exactly the same as in those birds which return hither in the spring, and in every respect their appearance was the same. These birds were exhibited to the Society for promoting Natural History, on the 14th February 1786, at the time when they were in a deep moult, during a severe frost, when the snow was on the ground. They died at last in the summer, from neglect during a long illness which Mr Pearson had, who concludes this interesting account with the following words: 'January 20, 1797.—I have now in my house, No. 21 Great Newport Street, Long-Acre, four swallows in moult, in as perfect health as any birds ever appeared to be in when moulting.'"[1] Our only other species is the sand-swallow, or bank-martin (*H. riparia*), of smaller size and browner colour. It is the earliest of the genus; but being more locally distributed, its arrival in many districts is not so speedily observed.

Among the foreign species, one of the most remarkable is *H. esculenta*, a small brown swallow, from the Indian Archipelago. Its nest, formed chiefly of a peculiar kind of sea-weed, is very mucilaginous when cooked; and its restoratory virtues are held in such high esteem, that it has become with eastern nations, especially the Chinese, a most important article of commerce. The best kinds (such as are white and transparent, and of a uniform and delicate texture) sell at from a thousand to fifteen hundred dollars the peckul (not more than twenty-five pounds). The Dutch alone were in use to export from Batavia about a thousand peckuls every year; but of these, a great proportion was brought from the islands of Cochin-China, and others to the eastward. However, these nests are nowhere more abundant than about Croee, near the south end of Sumatra. They weigh each about half an ounce, and resemble a small saucer in shape, with one side flattened, by which they adhere to the rocky walls of caverns. Their texture resembles that of isinglass, or fine gum-dragon. When about to be used they are soaked, then pulled to pieces; and after being mixed with ginseng, are put into the body of a fowl, which is stewed all night with a sufficient quantity of water. When dissolved in broth they are said to give it a delicious flavour.[2] Naturalists are not agreed as to the exact mode of formation of these nests. Some suppose them the result of a glandular secretion. Alexander Wilson says, that the aculeated swallow (*H. pelasgia*) of America fastens together the twigs which compose its nest by means of a strongly adhesive gummy matter, secreted by two glands placed on each side of the hinder portion of the head.[3] Insessores.

The swifts belong to the genus Cypselus of Illiger, distinguished by the extreme shortness of the legs, and the peculiar character of all the four toes being directed forwards. The middle and outer toes have only three articulations. Of all the feathered race, these are perhaps the most vigorous and unwearied flyers. Even in the skeleton, the shortness of the humerus, the breadth of its apophyses, the oval form of the fourchette, and the sternum unnotched below, indicate a structure admirably suited to sustain aërial motion; and when to these we add the enormously lengthened primary feathers of the wings, we have a flying machine of the most powerful kind. We doubt not that during every summer evening in which these sable creatures pursue their gladsome gambols through the unresisting air, they travel many hundred miles. It is easy to observe, that they are often on the wing incessantly for hours together, careering in fine weather in vast and intersecting circles, screaming after each other in no melodious strains, and flying at such a maddening rate as if flight were the only faculty worthy of exercise in earth or heaven; and we are sure that the same genius for arithmetic which enables a school-boy to ascertain how many grains of barley would surround the world, might, if applied to every minute's flight of this surprising bird for one "purpureal eve," elicit a result in distance which would astonish even a railway engineer. Our common swift is the *Cypselus murarius* of Temm. (*Hirundo apus*, Linn.). These birds, as well as swallows, seem in many instances to return to the same spot for a series of years. Dr Jenner took two claws from the foot of twelve swifts. Several were re-taken in the course of one or two seasons; and at the expiration of seven years, one was brought in by a cat. A larger species (*C. alpinus*, Temm.), frequent among the Alps of Switzerland and the Tyrol, and well known at Gibraltar, has occurred occasionally in Ireland. There are a great many foreign species, both of swifts and swallows.

In the genus Caprimulgus, Linn., the gape is still wider, and the beak is bristled at the base with stiffish hairs. The wings are very long, the legs short, the tarsi usually feathered, the toes united at the base by a membrane, slightly connecting even the hinder toe, which is somewhat versatile; the middle toe is often toothed on its inner edge (see Plate VII., figure 6 *a*); and the outer one, by a conformation of rare occurrence amongst birds, has only four articulations.

The Caprimulgi or goat-suckers (an absurd and fabu-

[1] Bewick's *British Birds*, i. 254.

[2] See Shaw's *General Zoology*, vol. x. p. 111; and Sir G. Staunton's *Embassy to China*, vol. i. p. 288, and vol. ii. p. 5. This species seems described under the name of *H. fuciphaga*, in *Act. Holm.* t. xxxiii. p. 151.

[3] *American Ornithology*, vol. ii. p. 24.

Insessores. lous term, which however, serves the best purpose of a name, in being generally understood to relate to the species in question) are solitary birds, which feed voraciously on insects, and fly about during the evening twilight, encroaching in mid-summer on the clear and stilly hours of night. Our only British species (*C. Europæus*) is a bird of passage; and in its beautifully brindled plumage of ashy-gray, brown, and black, with here and there a patch of white, presents a characteristic example of the genus. It frequents commons, heaths, and uncultivated tracts, especially where interspersed with brushwood. When on the wing, it utters occasionally a sharp hawk-like cry; but Cuvier surely errs when he asserts that "l'air qui s'engouffre, quand ils volent, dans leur large bec, y produit un bourdonnement particulier." If he alludes to the peculiar purring and prolonged sound which some compare to that of a spinning-wheel, there is no doubt of its being produced when the bird is at rest, on the top of a wall, or among a heap of stones. When perched upon a branch or paling, its position is peculiar. It rests horizontally in the same direction as that by which it is supported, instead of across or at right angles. Its flight, when pursuing moths and beetles, is very easy and graceful. The species of this genus are widely distributed. Three occur in North America; several in the southern parts of the new world; in New Holland they are well known; Africa produces some remarkable kinds; and those of Java and the East have been described by recent naturalists. Out of these, however, several subordinate genera have been created. The strong-billed species, which want the membrane between the toes, and the dentation of the middle claw, form the genus PODARGUS. They are natives of New Holland and the eastern islands. (See Plate VII., figure 6.) The great species from Guiana, which has the sides of the upper mandible dilated into a blunt tooth, constitutes the genus NYCTIBIUS of Vieillot. A very peculiar species (*Guacharo de caripe*), which feeds on fruits, and dwells gregariously in caverns, where the young are much sought after on account of their delicious fat, forms the genus STEATORNIS of Humboldt.[1] It is the only frugivorous night-flying bird with which we are acquainted.

Although the general title of goat-sucker is so familiar to our ears, we confess we were never aware of how it had originated,—deeming it some accidental and unmeaning application,—till we had read the following passage in Mr Waterton's work. "When the moon shines bright, you may have a fair opportunity of examining the goat-sucker. You will see it close by the cows, goats, and sheep, jumping up every now and then under their bellies. Approach a little nearer,—he is not shy,—'he fears no danger, for he knows no sin.' See how the nocturnal flies are tormenting the herd, and with what dexterity he springs up and catches them, as fast as they alight on the belly, legs, and udder of the animals. Observe how quietly they stand, and how sensible they seem of his good offices; for they neither strike at him, nor hit him with their tail, nor tread on him, nor try to drive him away as an uncivil intruder. Were you to dissect him, and inspect his stomach, you would find no milk there. It is full of the flies which have been annoying the herd."[2] Many an hour, during the long still summer evenings, have we watched the flight of our only British species, while it hawked for moths along the fringed margins of the rocky woods, or glanced more openly across the dewy meadows which bank the crystal basin of the "beautiful Winander,"—but we never saw it hovering around or near to any kind of cattle. We doubt not, however, that the same habit, as noted by Mr Waterton, must have been observed in Europe, and has, through misconception, originated the vernacular name. Insessores.

TRIBE 3D.—CONIROSTRES.

In this tribe are comprehended a considerable variety of genera, exhibiting not a little disparity in size, structure, and habits, but agreeing in their bills being comparatively strong, more or less conical, and without notch. Several of the species, such as crows and magpies, are omnivorous; but, generally speaking, when compared with either of the two preceding tribes, the diet of the Conirostres may be termed granivorous.

The first little group is constituted by the larks, genus ALAUDA, Linn., of which the greater number have the bill straight, moderately thick, and pointed. (See Plate VIII., figure 1.) Though their flight is occasionally lofty and sustained, and the sky-lark (*A. arvensis*) obtains its name

> From warbling high
> His trembling thrilling extacy,
> As, lessening from the dazzled sight,
> He melts in air and liquid light,—

yet they haunt, and build their humble nests, habitually in fields of grain or grassy meadows. Even the wood-lark (*A. arborea*), although it perches and sometimes sings on trees, rears its young upon the ground. The shore-lark of Pennant (*A. alpestris*, Gmel.) is common to the northern parts of Europe, Asia, and America.

In the genus PARUS, Linn., the bill is small, short, conical, straight, beset at the base with hairs, and the nostrils concealed by feathers. The species commonly called *titmice* are lively, active little birds, usually observed flying with eagerness from tree to tree in search of insects, scaling the branches in all directions, and seemingly quite regardless whether their heads or their heels are uppermost. Their nests are usually placed under cover, either in the crevice of a wall or the hollow of an old tree, and the number of eggs which they lay exceeds that of most Passeres. They eat grain and seeds, as well as insects. The species are distributed over the whole world, with the exception of New Holland, South America, and the islands of the South Pacific Ocean. Although of rather gay and beautiful plumage, they are more numerous in temperate and northern countries than between the tropics. We have seven species in Britain, of which the bearded titmouse (*P. biarmicus*) is scarce, and partially distributed, and the crested species (*P. cristatus*) so extremely rare as to be regarded as accidental. From the small size, rapid movements, and usually arboreous habits of all these birds, their doings can scarcely be observed with advantage during the umbrageous summer. But when the woods have either lost their leafy glory, or the dry red foliage hangs unresistant of the slightest breath, then are these vivacious creatures seen to congregate in little flocks, sometimes several species joining together, and cheering each other on with frequent shrilly cries. In their foraging excursions they likewise visit our gardens, shrubberies, and cottage doors, plundering the farm-yards, eating potatoes with the pigs and poultry, and greedily searching out an old marrow-bone, or (if in Scotland) a sheep's head of the preceding Sunday. The suspended nests of some of the foreign species are extremely elegant, and even that of our own long-tailed species is an object of great interest and beauty. Mr Selby describes it as usually fixed in one of the smaller forks of a tree branch, but occasionally amid the closer screen of a fir, or the centre of a thick bush of woodbine or thorn. It is of a longish oval form, composed of different

[1] *Acad. des Sciences*, Mars 1817, *Nouv. Bull.* 1817, p. 51.

[2] *Wanderings in South America*, p. 143.

Insessores. lichens and wool firmly and curiously interwoven, and lined with a profusion of feathers. A small hole is left on two opposite sides of the nest, not only for ingress and egress, but also to prevent the bird during incubation from being incommoded by its long tail, which then projects through one of the orifices. The eggs are white, with fine reddish-brown specks upon the larger end, and usually amount to ten or twelve.[1] The *Parus pendulinus*, a species of the southern parts of Europe, constructs a purse-shaped dwelling, suspended from the flexible branches of aquatic plants, or interlaced among the waving reeds. This hang-nest tit-mouse is often seen among the marshes of Bologna, where the peasantry seem to regard it with the same kindly affection as we do our red-breast.

The genus EMBERIZA, Linn., is distinctly characterized by its rather short, straight, conical bill, and the curved form of the gape, produced by a narrowing of the sides of the upper mandible, and a corresponding enlargement of the under one. Instead of being as usual concave within, the upper mandible has a hard, rounded knob in the inside, or what is called a tuberculous palate. The species commonly known by the name of buntings feed chiefly on seeds and grain. The ortolan (*E. hortulana*), a native of the central and southern provinces of Europe, has been occasionally killed in England. It is much esteemed in Italy and elsewhere as an article of food. It is frequently lean when first netted; but if left undisturbed and well fed, it will not only fatten rapidly, but even in many instances die of repletion. The snow-bunting, and a few other kinds, distinguished chiefly by the elongation of the hind claw, form the genus *Plectrophanes* of Meyer, now called lark-buntings by our English writers.

The great genus FRINGILLA of Linn. has the bill also conical, and more or less thickened at the base; but the commissure is not angularly curved, as in the preceding group. Numerous subdivisions have been made of this genus in modern times. Of these the following may be taken as examples.

In PLOCEUS, Cuv., the bill is rather square at the base, but sharp-pointed; the upper mandible somewhat dilated. The species are known by the name of weavers, on account of the art with which they join together the materials of their nests. Several species are gregarious, even during the breeding season, hanging their nests close together in the same tree; and as each on building a new nest forms it in close connection with the old, the final result is, that an apparently solid mass is at length collected, consisting of numerous apartments, each tenanted by a pair of birds, but having the external appearance of one gigantic dwelling. Cuvier here places the species known in the older systems as the Philippine gross-beak, *Loxia Philippina*, Linn. This bird is known in India by the name of baya, and may be rendered so tame as not only to perch upon the hand, but to fetch and carry at command. It builds a very curious nest, in the shape of a long cylinder, swelling out into a globose form in the middle, and composed of the fine fibres of leaves and grass, fastened by the end to a lofty branch, generally of the Palmyra or Indian fig-tree. The eggs are said to resemble pearls, with the white part transparent even when boiled, and are accounted delicious eating. This species is alleged to feed on fire-flies. Another remarkable Ploceus is the sociable gross-beak, or republican, *Loxia socia*, Latham. It is an inhabitant of the interior of the Cape country, and is thus described in Paterson's *Travels:* "Few species of birds live together in such large societies, or have such an extraordinary mode of nidification, as these; they build their nests on the mimosa trees, which grow to a very large size, and appear to be well calculated for the purpose, as the smoothness of their trunks prevents the birds from being attacked by monkeys, and other noxious animals. The method in which their nests are made is very curious. On one tree there could not be less than from eight hundred to a thousand under one general roof. I call it a roof, because it resembles that of a thatched house, and projects over the entrance of the nest below in a very singular manner. The industry of these birds seems almost equal to that of the bee. Throughout the day they appear to be busily employed in carrying a fine species of grass, which is the principal material they employ for the purpose of erecting this extraordinary work, as well as for additions and repairs. Though my short stay in the country was not sufficient to satisfy me by ocular proof that they added to their nest as they annually increased in numbers; still, from the many trees which I have seen borne down by the weight, and others which I have observed with their boughs completely covered over, it would appear that this is really the case. When the tree which is the support of this aërial city is obliged to give way to the increase of weight, it is obvious that they are no longer protected, and are under the necessity of rebuilding in other trees. One of these deserted nests I had the curiosity to break down, to inform myself of the internal structure of it, and found it equally ingenious with that of the external. There are many entrances, each of which forms a regular street, with nests on both sides, at about two inches distance from each other. The grass with which they build is called the Boshman's grass, and I believe the seed of it to be their principal food, though, on examining their nests, I found the wings and legs of different insects. From every appearance, the nest which I dissected had been inhabited for many years, and some parts of it were more complete than others. This, therefore, I conceive to amount nearly to a proof that the animals added to it at different times, as they found necessary, from the increase of the family, or rather of the nation or community."[2] Insessores.

The genus PYRGITA, Cuv., contains the sparrows properly so called, of which the common house species (*P. domestica*) affords a familiar example. This bird is characteristic of the temperate and more northern parts of Europe, and is scarcely known in Italy to the south of Piedmont, being replaced by a closely-allied species, *P. cisalpina*, which is the *Passer volgare* of Italian authors. Although M. Temminck thinks that the manners of the latter are less domestic than those of our more northern kind, and that its love of fields and country places ally it rather to the *P. montana*, we doubt not that all who have lived in Italy will be of a contrary opinion,—in agreement with the following beautiful passage by Professor Savi, which we shall not injure by translating. "Sembra che quest' uccello non possa vivere se non con l'uomo. Eccetuate quelle regioni alpestri ove regnano perpetuamente i ghiacci, in qualunque altro luogo in cui l'uomo si è stabilito, la Passera l'ha accompagnato; e indifferente alla prospera, o contraria fortuna, essa ha posta dimora nella dimora di lui. In riva delli stagni, in mezzo alla quiete de' boschi delle Maremme, sulla povera ed umile capanna d'un piscatore o d'un pecorajo, han domicilio le passere, le quali trovano il loro cibo nella sementa di grano del piccolo campo, ne' frutti dell' orticello, nello scarso becchime gettato alle galline o a' piccioni. E nel modo stesso voi le vedete nel contro delle più grandi e clamorose città, porre il nido fra gli ornati d'una grandiosa cattedrale, o sù i tetti d'un giardin di delizia, e cercare le granella o miche di pane in mezzo alle piazze più popolate. Ma se l'uomo cessa d'abitare

[1] *British Ornithology*, i. 241.

[2] *General Zoology*, vol. ix. p. 303.

Insessores.

quella capanna, o quella città, la passera anche essa l'abbandona. Chi, girando nelle maremme, passa per antiche e disabitate abbazie, per fortilizi, o ville in rovini, vedra dalle finestre più elevate di quelle, fuggire de' piccioni insalvatichiti, udirà gridar la civetta che abita fra li spacchi de' muri vestiti d'ellera e parietaria, vedrà la ballerina continuare a fabbricarvi il nido, ma in vano egli la cercherà il volatile parasito dell' Europeo, quella specie d'uccello che prima per il numero ogni altro ne superava in quel luogo. Così nel modo stesso che una figura geometrica vista sulla sabbia fu giudicata dal naufraga Filosofo per un segno certo della vicinanza dell'uomo, per un tal segno ancora può ritenersi la presenza delle passere."[1] In regard to our own species, Savi observes, "non mi è noto se ne stiano anche in Lombardia, ma so di certo che alcuno giammai ne è stato visto in Toscana." According to Temminck, the boundary of the latter species is the great chain of the Alps, on the southern slopes of which it disappears in favour of the cisalpine kind. But it is our common British sparrow which occurs about Trieste, and through the north of Dalmatia, although separated from the region of *P. cisalpina* only by the waters of the Adriatic. "I costumi," adds the Italian author, "di queste due specie sono precisamente gli stessi. Io ho accuratamente ed in varj tempi osservate le abitudini della *F. domestica*, tanto in Svizzera che nel settentrione della Francia, e posso assicurare che le stesse sono di quelle della nostra specie Italiana."[2]

In the restricted genus FRINGILLA, Cuv., the bill is rather less arched than in the sparrows, and a little stronger and more lengthened than among the linnets. Cuvier includes in it the chaffinch (*F. cœlebs*), the mountain-finch or brambling (*F. montifringilla*), and the snow-finch (*F. nivalis*). The latter is scarcely ever found except in the near vicinity of ice and snow, and may be regarded (in common with *Accenter alpinus*) as the most mountainous of all the smaller birds of Europe. Yet though wild and solitary in our estimation, from associating it with the desolate scenery of the rock-surrounded glaciers, it is beautiful to see how, in the neighbourhood of the lonely shepherd chalets of the Alps, it loves to humanise its feelings; and how, among the few sad dwellings of the Mount Cenis, and other lofty passes, it perches on the roofs of houses, hops about the beaten foot-paths, and builds among dismantled yet protecting walls. In winter it seeks subalpine regions, or the snow-covered valleys of Piedmont, but scarcely ever migrates to the lowest plains. It is unknown in Tuscany.

In the genus CARDUELIS, Cuv., the bill is more exactly conic, without bulging in any portion, and is rather lengthened. We may name as an example, our beautiful, lively, and intelligent goldfinch (*C. elegans*, Steph.,—*F. carduelis*, Linn.), a bird widely distributed over Europe, and extending from the sultry shores of the Mediterranean to the plains of Siberia. It occurs in Holland only as a bird of passage. The siskin (*F. spinus*) is by some considered as a Carduelis, while others place it with the group which follows, viz. genus LINARIA, Bechstein, in which the bill is equally conical, but not so long. Here we place our gray linnets and red-poles, among which the more or less decided crimson tinting of the breast and forehead, according to age and season, has occasioned some confusion. Our common or gray linnet (*F. cannabina*, Linn.,—*F. linota*, Gmel.) is, in the perfect nuptial plumage, synonymous with the rose-linnet and greater red-pole. Our lesser red-pole is the *F. linaria* of Linn.; and the only other British species is the twyte or mountain-linnet, *F. montium*, Gmel., formerly regarded as a bird of passage, but now known to breed in the northern counties of Scotland, if not elsewhere in Britain. We have caught the young ones, half-fledged, among the Grampian Mountains. The amount of foreign species is considerable. Of these, one of the most remarkable for its musical powers is the well-known canary (*F. canaria*, Linn.), a native of the Cape de Verd and other islands, where its natural plumage is green. It breeds readily in confinement with the linnet, goldfinch, siskin, and other species.

Insessores.

The genus VIDUA, Cuv., contains some remarkable species, with the bill more inflated at the base than the preceding, but chiefly characterized by the extreme elongation of the caudal plumage of the males. They inhabit India and Africa, and were placed by Linnæus among the buntings.

The genus COCCOTHRAUSTES, Cuv., containing the gross-beaks, has the bill very conical, but of extreme thickness at the base, and rapidly tapering to the point. The culmen is rounded, the commissure slightly arched. The species occur in America, as well as in the ancient continents. The haw-finch (*C. vulgaris*,—*Loxia coccothraustes*, Linn.) visits the southern parts of Britain occasionally during winter, and is even said to have been found breeding in Windsor Forest. It feeds upon the larger kinds of seeds and berries, which it is enabled to bruise and break at pleasure, by means of the great strength of its bill. The evening gross-beak (*C. vespertina*, Cooper) is a beautiful American species, with the frontal feathers and a line above the eye yellow, the crown, wings, and tail black, the secondaries and inner wing-coverts white, the bill pale yellow. This newly-discovered bird inhabits the solitudes of the north-western interior, being met with from the extremity of the Michigan territory to the Rocky Mountains, and it is not uncommon towards the upper end of Lake Superior and the borders of the Athabasca Lake. To the east of these regions it appears to be only a transient visitor during spring and autumn. Our homely and heavy-headed green linnet (*C. chloris*, Fleming), of which the mature male is a rich and beautifully plumaged bird, belongs to our present genus. It is probable that the *Fringilla incerta* of Risso, figured by M. Roux (in his *Ornithologie Provençale*), is nearly allied. It is one of the rarest of the European birds, appearing occasionally during the autumn in Provence, and likewise occurring in the vicinity of Palermo.

In the genus PITYLUS, Cuv., are contained a few species (almost all, we believe, from South America), in which the bill, though thick, as in the preceding, is rather compressed, arched above, and has sometimes a projecting angle in the middle of the margin of the upper mandible. Such are the *Loxia grossa*, *Portoricensis*, &c.

In the genus PYRRHULA, in which the bill is shorter and greatly bulged, we have the bullfinches, of which our British species, *P. vulgaris*, Temm.,—*L. pyrrhula*, Linn., is a well-known example. It is very generally distributed throughout our wooded districts, but is nowhere very abundant, and may be called scarce in several quarters of the island.

In the genus LOXIA of Brisson, as now restricted, the bill is compressed, and the two mandibles so curved and deflected, that when closed they cross each other. This extraordinary structure is supposed to afford the species great facility in stripping the scales from the well-protected seeds of the various kinds of pine-trees. The crossbills are few in number, and occur both in Europe and America. Their habits as breeding birds are little known, but the period of incubation must be very early, as *L. curvirostra* sometimes visits this country in small flocks as early as June. Temminck says, somewhat vaguely, in regard to the parrot-billed species (*L. pytiopsittacus*), that it "niche en hiver dans nos climats, sur les branches de sapin; en Livonie l'espèce niche dès les mois de Mais."[3]

[1] *Ornitologia Toscana*, t. ii. p. 100.

[2] *Ibid.* p. 106.

Insessores. Their chief haunts are probably within the arctic circle. In America they are believed to breed about Hudson's Bay, being seen in the United States only from September to April. It thus appears, at all events, that they do not there breed during the winter season.

The great pine gross-beak (*Loxia enucleator*, Linn., by some regarded as a bullfinch) may be here named as belonging to the genus Corythus of Cuvier. It is a northern species, occurring in the colder regions both of Europe and America. Although Pennant mentions having met with it in the woods of Invercauld in the month of August, we are not aware of its having ever since been seen in Scotland.

In the genus Colius, Gmelin, the bill is short, thick, conical, somewhat compressed, both mandibles arched, and of nearly equal length. The feathers of the tail are long and graduated, and the plumage, for the most part fine and silky, is usually ash-coloured. The hind toe can assume a forward direction, almost as in the swifts. (See Plate VIII., figure 3.) The species are found in India and Africa. Prior to the time of Vaillant, we knew little of their habits. They are now known to be gregarious, endowed with but feeble powers of flight, but almost as skilful as parakeets in climbing. They are not at all addicted to insect food; but their love of fruits, and the tender buds of trees, makes them very injurious wherever land is under horticultural care. They not only dwell together in society, but build their nests in little groups upon the same thorny bush. They are moreover distinguished by a singular custom of sleeping close together, suspended head downwards from the branches. The species here represented (Plate VIII., figure 2) is *C. leuconotus*, Lath. (*C. erythropus*, Gmel.), supposed to be identical with *C. capensis*, Linn.

The genus Buphaga of Brisson has the bill square at the base, and rather gibbous towards the point, which is abbreviated. The species, only two in number, are insectivorous, and have derived the name of beef-eaters from their habit of picking larvæ from the hides of the larger kinds of cattle, thus freeing them from noxious parasites. The South African species (*B. Africana*, Linn.) was observed by Vaillant in the country of the Namuquas in small flocks. He found it shy, and difficult to be approached. The other species referred to this genus is the *B. erythrorhyncha* of Temm., common in the north-eastern countries of Africa, where it follows caravans for the sake of picking insects from the woolly backs of camels, and other beasts of burden. It is singular, that although hitherto unknown in Southern Africa, it should have been received from Madagascar.

In the genus Cassicus of Cuv. the bill is much more exactly conical, thick at the base, extremely sharp pointed, the commissure forming an angulated line as in the starlings. These are American birds of gregarious habits, which feed both on fruits and insects, and frequently exhibit such surprising skill and ingenuity in the structure of their nests, that an old lady once gravely asked an American Ornithologist whether he did not think they might be taught to darn stockings. In the genus Cassicus properly so called, the base of the bill ascends upon the forehead, so as to encroach broadly upon the frontlet feathers. Here are contained the largest species. The one we have figured (*C. cristatus*, Plate VIII., figure 5) is from Cayenne. In the genus Icterus the bill is arched, and does not extend upon the forehead except by a sharp notch.[1] With the Icteri Cuvier combines the purple grakle, or crow blackbird of America (*Quiscalus versicolor* of Vieillot), between which and the fish-hawk a singular understanding seems to be kept up. The nest of the latter is of large dimensions, often from three to four feet in breadth, and from four to five feet high, composed externally of large sticks or faggots, among the interstices of which several pair of crow blackbirds will construct their nests, while the hawk sits hatching over all. These birds are very injurious to the crops of Indian corn, and sometimes collect in prodigious flocks, descending on the fields like a blackening tempest. They occupy a great extent of territory, being widely spread from Hudson's Bay to within the tropics. They are migratory in the colder districts, and on their first arrival feed on insects as well as seeds.[2] According to Dr Richardson, their first appearance on the plains of the Saskatchewan is very striking. They arrive from their southern winter quarters in the beginning of May, the males and females in separate flocks of from twenty to a hundred, which perch in crowds upon the leafless branches of the trees, their plumage shining with metallic splendour. Insessores.

The genus Xanthornus (*les carouges*) scarcely differs from the preceding, except that the bill is straight. Here Cuvier places many of the American orioles, such as the red-shouldered species (*O. phœniceus*, Linn.). These "red-winged starlings," as Wilson calls them, are generally migratory in the states north of Maryland, but are found during winter in immense flocks along the lower parts of Virginia, both Carolinas, Georgia, and Louisiana, particularly near the sea-coast, and in the vicinity of large fields of rice and corn. "In the months of January and February, while passing through the former of these countries, I was frequently entertained with the aërial evolutions of these great bodies of starlings. Sometimes they appeared driving about like an enormous black cloud carried before the wind, varying its shape every moment; sometimes suddenly rising from the fields around me with a noise like thunder; while the glittering of innumerable wings of the brightest vermilion amid the black cloud they formed, produced on these occasions a very striking and splendid effect. Then descending like a torrent, and covering the branches of some detached grove, or clump of trees, the whole congregated multitude commenced one general concert or chorus, that I have plainly distinguished at the distance of more than two miles; and when listened to at the intermediate space of about a quarter of a mile, with a slight breeze of wind to swell and soften the flow of its cadences, was to me grand, and even sublime. The whole season of winter, that with most birds is past struggling to sustain life in silent melancholy, is with the red-wings one continued carnival. The profuse gleanings of the old rice, corn, and buck-wheat fields, supply them with abundant food, at once ready and nutritious; and the intermediate time is spent either in aërial manœuvres, or in grand vocal performances, as if solicitous to supply the absence of all the tuneful summer tribes, and to cheer the dejected face of nature with their whole combined powers of harmony."[3]

In this genus some have also placed the noted cow-pen bird of Catesby (*Icterus pecoris*, Bon.; *Emb. pecoris*, Wilson), of which the most remarkable feature consists in its

[1] For a detailed classification of the Icteri of Brisson, see Mr Vigors's "Sketches in Ornithology," *Zoological Journal*, No. vi. p. 182.

[2] Great confusion exists in the nomenclature of these birds, and of their congeners the troupials, hang-nest orioles, and other American species, chiefly in consequence of the transposition of names. Almost every author has composed his groups of different materials, and of course has applied his designations differently. The genus *Quiscalus* of Vieillot contains four well-ascertained species, *Q. major*, *versicolor*, *ferrugineus*, and *baritus*.

[3] *American Ornithology*, vol. i. p. 193.

Insessores. depositing, like our European cuckoo, its eggs in the nests of other birds. The circumstances by which Wilson first became acquainted with this peculiar habit are as follows. He had in numerous instances found in the nests of three or four particular species, one egg much larger and differently marked from those beside it. He at length detected the female of this cow-bunting, as he calls it, in the act, that is, sitting in the nest of the red-eyed fly-catcher, (her eyes might well be red, if she had ever fondly hoped for a legitimate posterity), which happens to be a very small one, and singularly constructed. Suspecting her purpose (and truly her position was more than suspicious), he cautiously withdrew without disturbing her, and had the satisfaction to find on his return, that she had left an egg exactly like that just alluded to. He afterwards, in many instances, found the young cow-bunting in the nest of these and of other birds, and also observed the latter followed by a foster child calling most clamorously for food. The cow-bird is gregarious and migratory, entering the middle and northern states about the end of March or beginning of April, and passing northwards as the season becomes milder. It arrives in the fur-countries in May, ranges to the sixtieth parallel, departs in September, and collects in large flocks in Pennsylvania during the following months, after which it retires to winter in the more southern states and Mexico. Its food consists of grain, grass, and worms, particularly certain intestinal ones, which it finds in the dung of cattle. The cow-bunting never pairs, and a state of general concubinage seems to prevail amongst them. Bred up as foundlings in the nests of other birds, and fed by foster parents,—owing their existence and preservation to a system of cunning deception, and commencing their career by the destruction of the natural inmates of that mossy dwelling in which they passed their own delusive infancy,—what hopes can here be cherished of the hallowed growth of home affections? When the female is disposed to lay, she appears restless and dejected, and separates herself from the unregarding males, who care not for posterity. Stealing through the woods and thickets, she pries insidiously into every bush and branch for a nest that suits her fancy, and into it she darts in absence of the owner, and in a few minutes is seen to rise upon the wing, relieved from all maternal care. If the egg be deposited alone, that is, in a previously empty nest, it is almost uniformly forsaken; but if the nursing mother has any of her own she immediately begins to sit. The red-eyed fly-catcher (*Vireo olivaceus*) proves a most assiduous foster-parent. In the beautiful basket-like nest of one of these birds, Mr Nuttall found an egg of each species, and the female fly-catcher already sitting. He removed her own egg, and left that of the stranger. She soon returned, and, as if sensible of what had happened, gazed steadfastly, shifted the egg, sat on it for a time, moved off, renewed her observation, and at length settled down upon her nest. Two or three days after, however, she was found to have left the premises. Yet another bird forsook two eggs of her own, because that of the cow-bird was taken away,—which proves that there is no accounting for tastes. The blue bird, which exhibits a strong attachment to its breeding places, affords one of the few examples of a species not refusing to lay after the stranger's egg has been first deposited. Mr Pickering observed two nests of the blue-eyed yellow warbler, in which, previous to their own laying, an egg of the cow-bird had been deposited, and finding themselves unable to eject it, the warblers buried it in the bottom of the nest, by building over it an additional story! The egg of the cow-bird, perhaps from being larger, and coming thus into closer contact with the body of its nurse, is sooner hatched than the others. The produce of the latter, though often stifled, Insessores. are sometimes reared along with the intruder. If the natural offspring die, they are found lying at some distance from the nest, and not directly beneath it, which shows that they are carried out by the parents, and not heaved over by the giant intruder, as in the case of our European cuckoo. When fully fledged, the cow-bird soon deserts his foster-parents, and skulks for a time about the woods, till he instinctively joins a few of his own blood, and then he seeks his food more boldly (five or six together), in the fields and lanes.[1] This bird measures about seven inches in length. The head and neck are blackish-brown, the rest black, glossed above with green, and on the breast with violet.

The Baltimore oriole is another beautiful species of Icterus,—*I. Baltimorus*. The male is orange, with the head, neck, upper part of the back, and greater portion of the wings, black. It winters in South America, but makes its appearance in the United States in spring, where its arrival is hailed as the sure harbinger of warmth and sunshine. Full of life and activity, it is seen vaulting like a fiery sylph among the boughs of lofty trees, vanishing with restless inquietude, and again flashing quickly into sight from amidst some wreath of waving foliage, showing like a living gem amid the green adornment of the leafy forest. The most remarkable instinctive feature of this bird is displayed in the structure of its nest, which consists of a pendulous cylindrical pouch of six or seven inches in depth, usually suspended almost from the extremity of some lofty drooping branch. The materials, according to Wilson, are flax, hemp, cow-hair, and wool, woven into a complete cloth, the whole being tightly sewed through and through with long horse-hairs, several of which measure two feet in length. The bottom is composed of thick tufts of cow-hair, also sewed, and strengthened with strong horse-hair. The materials, however, vary, and so solicitous is the bird to procure the best that can be possibly obtained, that during the building season the women in the country are under the necessity of narrowly watching their thread when bleaching.

The genus Oxyrhynchus, Temm., has the conical sharp-pointed bill of the Icteri, but it is shorter than the head. Example, *O. cristatus*, Swainson's *Illustrations*, vol. iii. pl. 49,—a Brazilian species. The genus Dacnis of Cuvier is formed by the *Motacilla cayana* of Linn.

The genus Sturnus, Linn., also resembles the Icteri; but the bill is depressed towards the extremity. There are two European species, one of which, our common starling (*S. vulgaris*), is well known in many parts of Britain, and is remarkable for its gregarious habits, and singular aërial movements. Its glossy black and purple plumage, starred with little spots of white, render it a very ornamental bird; and the great facility with which it may be taught to speak makes it much sought after as a domesticated species. *S. unicolor* inhabits Sardinia and the South of Europe.

Baron Cuvier concludes the conirostral tribe with three well-marked groups, the crows, the rollers, and the birds of paradise.

In the genus Corvus, Linn., the bill is strong, straight, rather long, compressed towards the point, the nostrils covered by stiff, reversed feathers. The plumage, though generally dense and dark, is soft and lustrous, and the species bear so great a resemblance to each other, that, as Dr Macgillivray observes, the most unpractised observer can scarcely fail to distinguish a crow. They also exhibit corresponding instincts, being, if not shy, at least cunning and watchful. They are omnivorous in the fullest sense of the term, and will poke their beaks into every thing

[1] Nuttall, vol. i. p. 178.

Insessores. they can find, from a boiled potato to a dead horse. "When searching for food, they betake themselves to open places, walk in a sedate manner, keep a good look out, and on the least appearance of danger fly off to a distance. Their flight is also sedate, moderately rapid, and performed by regular beats. Their cry varies from a hoarse croak to a caw or chatter, and some of them are musical. They nestle in high places, trees, towers, buildings of various kinds, or rocks; and produce from three to nine eggs, which are deposited very early in the season. They repose at night in similar places, and when alarmed by day generally take themselves to heights. Some species are gregarious, others unsocial,—the latter being the more carnivorous; but even they are observed to associate together when a large quantity of food attracts them to a particular place. The sexes do not differ much in external appearance; the male, however, being in general more robust, and having the plumage more glossy. Moulting takes place in the summer months, and is very gradual. Those which are more carnivorous have the faculty of discovering carrion at a great distance, in the same manner as the vultures, which they in some degree resemble in their habits. They are all easily tamed, and may be taught to imitate the human voice so far as to produce a few articulate sounds. In a state of domestication they are much addicted to pilfering, their depredations not being confined to articles of food, but extending to objects in no respect useful to themselves."[1]

Five species of crow occur in Britain, all permanent dwellers, viz. the raven (*C. corax*), the carrion-crow (*C. corone*), the hooded crow (*C. cornix*), the rook (*C. frugilegus*), and the jackdaw (*C. monedula*). We shall not describe the external aspect of these birds, which, we doubt not, are familiar to our readers. The raven in a state of nature is remarkable for his great cunning and sagacity, while in the domesticated condition he is extremely frolicsome and full of humour. We have seen one that, while engaged in amusing himself with a poodle dog, and unable to keep pace with his four-footed play-fellow, would seize him by a lock of hair, and hold on tenaciously while the dog was careering at full gallop; and his numerous devices, with a view to conceal the remnants of his own food, or appropriate that of others, were varied and unceasing. This species is widely spread over the temperate and northern parts of Europe and America, and in the minds of the ignorant is usually regarded with some degree of superstitious terror. In summer, when the sky is serene, he flies in circles in the higher regions of the clear blue sky, and his deep and solemn croak may be heard at a great distance; but he is said to be sometimes also seen in the midst of thunder-storms, with the electric fire streaming from the point of his bill!—an extraordinary phenomenon certainly (if true), sufficient to terrify the superstitious, and to stamp its subject with the character of a restless and indestructible demon.

The carrion-crow, and the hooded species, are so like in size and structure, that it would be scarcely possible to distinguish them, but for the partially gray plumage of the latter; and as a black and a gray crow are often seen together, some naturalists incline to the belief that they are actually the same. Their geographical distribution, however, seems to differ; the gray kind, though common in Britain and the continental countries of Europe, being unknown in America, where, at the same time, the carrion-crow is described as identical with our own; while, on the other hand, we find the latter extremely rare in the north of Italy, where the hooded crow abounds. The jackdaw and the rook seem unknown in the western world.

The magpies (genus Pica, Cuv.) are of smaller dimensions than the crows properly so called, and their tails, instead of being either round or square, are long and graduated. Their dispositions, however, are equally omnivorous, and they are distinguished by the same sly and furtive cunning. There is only a single European species, our common British kind (*C. pica*, Linn.), which occurs all over Europe, and is well known in North America, and some parts of Asia. Many beautiful species occur in China, and other eastern countries, such, for example, as the red-billed pie, *P. erythrorhyncha*, Gould. Its size exceeds that of our common kind, and the great length of its tail bestows upon it a still more slender and elegant aspect. The prevailing colours are blue, with bars of black and white. It is often kept in aviaries, where it is highly esteemed, on account both of its docility and beauty. This species likewise inhabits the Himalaya Mountains, and there is reason to believe that it is fierce and tyrannical in a state of nature. Mr Shore states, that one which he kept in captivity, although it refused other food, pounced ferociously upon living birds, which were presented by way of experiment, and eagerly devoured them. When seen amid the foliage of trees, it forms an ornamental and conspicuous object, flitting from bough to bough, its long and flowing tail waving in the wind, and its whole form full of vivacity and grace.[2] The Chinese magpie (*P. sinensis*), made known by the researches of General Hardwicke, seems widely extended over tracts of land of very various character as to height and situation. It inhabits the higher portions of the Himalayas, the plains at the base of those mighty mountains, and a great part of the Chinese empire.

The beautiful jays (genus Garrulus, Cuv.) are very nearly allied to the magpies, but the tail is not so lengthened, and the culmen of the under mandible is rather more convex. Our British species (*G. garrulus*) is one of the most ornamental of our indigenous birds. It dwells in woods, beyond the outskirts of which it seldom wanders. Its food consists of insects, fruits, and forest seeds. Species of this little group are found in every quarter of the known world except New Holland. The blue jay of America (*G. cristatus*, Plate VIII., figure 4) is an almost universal inhabitant of the western woods, frequenting the thickest *settlements*, as well as the deepest recesses of the unpeopled forest,—where his harsh voice often alarms the watchful deer, to the mortification of the disappointed huntsman. This species is a bitter enemy to owls, one of which he no sooner discovers than he summons the whole feathered fraternity to his assistance, and the united mob proceed to vent their indignant spite against the blinking solitary, in the most wrathful and unmeasured manner. But this jay himself cannot be held guiltless of the most owl-like depredations,—for he becomes in his turn the very tyrant he detested, and sneaks through wood and thicket, plundering every nest his poking bill can reach to, gobbling up the eggs, tearing the callow young to pieces, and spreading not only fear, but death, and sorrow, its sad concomitant, around him. Another very ornamental species—

> Proud of cærulean stains
> From heaven's unsullied arch purloined,

is that mentioned by Pallas as having been shot by Steller when Behring's crew landed upon the coast of America. It is the *Corvus Stelleri* of Latham, by whom it was first described from a specimen in Sir Joseph Banks's collection from Nootka Sound. A larger and most magnificent bird is the Columbia jay (*Garrulus Bullokii*, Wagler,—*G. gubernatrix*, Temm.), figured in Mr Audubon's splendid work. The colour is bright blue, with a lofty crest of separate plumes, the throat and breast black, the abdomen whitish

[1] Macgillivray's *British Birds*, i. 496.

[2] *Century of Birds from the Himalaya Mountains*, plate xli.

Insessores. and two of the central tail-feathers extending far beyond the others. It occurs chiefly in Mexico and California.[1]

In the genus CARYOCATACTES, Cuv., both mandibles are equally pointed, and straight to the tips. The only species known in Europe, called the nut-cracker (*C. nucifraga*), is an occasional visitant of Great Britain. Two others have of late years been discovered in Asia, one of which is figured by Mr Gould. They are all believed to inhabit forests, especially those of mountainous countries, whence at certain seasons they emigrate in large flocks. In their climbing tendencies they make an approach to the habits of the woodpeckers.

The limited genus TEMIA, Vail., with the lengthened tail and general proportions of the magpies, has the bill elevated, the upper mandible bulged, and its base covered by short velvety feathers. Example, *Corvus varians*, Lath. (*Phenotrix temia*, Horsfield), of which the general plumage is bronzed green, the head black. It occurs in Java and elsewhere.

In the genus GLAUCOPIS, Forster, the bill resembles that of the preceding; but its base bears a pair of fleshy caruncles. *G. cinerea* is the only known species. It is a native of New Zealand, and was discovered during Captain Cook's voyage. Its flesh is excellent. It is the cinereous wattle-bird of Shaw. M. Temminck joins this and the preceding genus into one.

In the genus CORACIAS, Linn., containing the rollers, the bill is strong, compressed towards the point, which is slightly curved, and the nostrils are oblong, not covered by the feathers, but placed at their margin. The feet are short and strong. These birds are confined to the ancient continents, and are remarkable for their beauty of plumage, of which the colours are usually different shades of purple, blue, and green. They are said to be wild and unsociable, feeding on insects, and keeping themselves concealed in the retirement of thick forests. The European species (*Coracias garrula*, Linn.) has been sometimes seen in Britain. A specimen in the Edinburgh Museum was killed at Dunkeld. Although rare in France, it is by no means uncommon in Sweden, where we would not expect to find a species characteristic of the south of Europe, and which is believed to winter in Barbary and Senegal. It is not unfrequent in the gardens of Rome, and is common in the Morea. It becomes very fat in autumn, and is much sought after during that season as an article of food, especially by the inhabitants of the Cyclades. Several other kinds occur in Africa and the East. Of these the Abyssinian species is distinguished by the elongation of the lateral feathers of the tail. The Madagascar roller, and some allied kinds, distinguished by a shorter, more arched, and greatly broader bill, belong to the genus COLARIS, Cuv., synonymous with *Eurystomus* of M. Vieillot.

The genus PARADISEA, Linn., with which we conclude our abridgment of the conirostral tribe, contains the famous birds of paradise, so noted during our early intercourse with eastern countries. The bill is straight, compressed, rather strong, unnotched, the nostrils surrounded by a close tissue of feathers of a velvet texture, sometimes resplendent with metallic lustre. (See Plate VIII., fig. 8.) These birds are native to New Guinea and the neighbouring islands, and in consequence of the delicately graceful structure of their plumage, and the pure and beautifully blended colours by which they are adorned, the species in general may be regarded as the most highly prized of all the feathered race. Their history was long obscure as night, and even now we have but few features of their character developed by the actual observation of trustworthy witnesses. We cannot be here expected to throw any new light upon the subject; but we shall give a portion of the information which we have acquired from various authors. Insessores.

In the second edition of Pennant's *Indian Zoology*, there is a general description of the genus from Valentyn and other writers, by Dr J. R. Forster, preceded by a learned disquisition on the fabulous phœnix of antiquity, a bird of the size of an eagle, decorated with gold and purple plumes, and more particularly described by Pliny as being characterized by the splendour of gold around the neck, with the rest of the body purple, the tail blue varied with rose-colour, the face adorned with combs or wattles, and the head furnished with a crest. This excellently adorned phœnix Dr Forster very properly supposes to have been no other than a symbolical Egyptian illustration of the annual revolution of the sun, and the conversion of the great year, which, according to Manilius, corresponds with the supposed life of the phœnix, and from which period the same course of seasons and position of the heavenly bodies are renewed. Now, though it is certain, as Dr Forster observes, that the birds of paradise were never known to ancient writers, and that whatever the Egyptian priests delivered concerning their fabulous phœnix has no apparent agreement with the birds in question, yet it is remarkable enough that the names applied to them, both by Indian and European nations, attribute something of a supposed celestial origin. Dr Shaw, however, thinks that this notion has in all probability arisen merely from their transcendent beauty, and the singular and delicate disposition of their plumage. The Portuguese who navigated to the Indian islands called them *Passaros da Sol*, in like manner as the Egyptians regarded their imaginary bird as symbolizing the annual revolution of that great luminary. The inhabitants of the island of Ternate call them Manuco-Dewata, or the Birds of God.[2]

The great bird of paradise (*Paradisea apoda*, Linn., so called from its supposed want of legs), the first of the genus made known to Europeans, was imported about the year 1522, by Antony Pigafetta, who accompanied Magellan in his voyage round the world. Pigafetta was satisfied by ocular demonstration from the first, that this bird, like every other, was supplied with legs, but that the natives cut them off, as parts of no importance. In consequence, however, of this prevailing if not universal mutilation, a notion soon obtained in Europe that the bird was naturally destitute of these common-place but useful organs, and that consequently it floated for ever in the air, winnowing with loving wings the gentle breezes, or at times suspending itself for a few brief moments from some lofty sun-illumined tree, by the two peculiar lengthened filaments with which it is adorned. In accordance with this belief, it was of course consistent to suppose, that whatever individuals were obtained "on this dim spot which men call earth," had fallen from their aërial heights immediately before their dissolution. Even Aldrovandus, the most zealous naturalist of his age, having himself seen only such specimens as had been mutilated in the usual manner, accuses Pigafetta of audacious falsehood in asserting that the bird was naturally furnished both with legs and feet; and the great Scaliger, himself a naturalist of no mean order, gave equal credit to this foolish fancy.

The true residence or breeding-place of these birds seems to be Papua or New Guinea, from whence they make occasional excursions to some smaller neighbouring islands. They fly in flocks of about thirty or forty, led, it is alleged, by a single bird which the natives call their king, but which is said to be of a different species. It is further pretended, that when this bird settles, the whole flight settle also, in consequence of which they sometimes

[1] *The Birds of America*, plate xcvi.

[2] Shaw's *General Zoology*, vol. vii. p. 479.

Insessores. perish, being unable to rise again owing to the peculiar structure of their wings. They also always fly against the wind, lest their flowing plumage should be discomposed. While flying they make a noise like starlings, but their common cry rather resembles that of a raven, and is very audible in windy weather, when they dread the chance of being thrown upon the ground. In the Aru Islands they are seen to perch on lofty trees, and are variously captured by the inhabitants, with bird-lime, snares, and blunted arrows. Though many are taken alive, they are always killed immediately, embowelled, the feet cut off, the plumed skins fumigated with sulphur, and then dried for sale. The Dutch ships frequenting the sea between New Guinea and Aru, a distance of about twenty miles, not unfrequently observe flocks of paradise birds crossing from one to the other of these places, but constantly against the wind. Should a gale arise, they ascend to a great height, into the regions of perpetual calm, and there pursue their journey. With respect to their food we have little certain information from the older authors, some of whom assert they prey on small birds, a supposition which Dr Shaw inclines to think is favoured by their strength of bill and legs, and the vigour with which they act in self-defence. They are also said to feed on fruits and berries; and Linnæus says they devour the larger butterflies.[1]

We owe the following observations to M. Gaimard, one of the naturalists who accompanied the expedition of Captain Freycinet, and who having had an opportunity of seeing several living birds of paradise in the island of Waigiou, has furnished us with some interesting details. He says that they appear to prefer to all other places the most dense and secluded portions of the forests. When the heavens are clear, they perch habitually on the summits of the tallest trees. They fly with rapidity, but in an undulating manner, as is usual with birds which are adorned with long decomposed or disunited feathers; and he confirms the old account, that the luxuriant length of their superb plumage induces them always to fly in the direction from which the wind proceeds. "Cette manœuvre," he observes, "est pour eux très-naturelle, puisqu'elle maintient les longues plumes appliquées contre le corps; dans une direction contraire, le vent ne manquerait pas d'étaler et de relever ces plumes, et il en résulterait nécessairement un grand embarras dans le jeu des ailes." Their total disappearance on the approach of any storm or tempest shows their conscious weakness. In other respects, however, they are courageous, and even vindictive, pursuing fiercely any supposed enemy, however superior to themselves in strength of bill and talons. There is no instance, Captain Freycinet supposes (we now know he does so erroneously), of their being ever reduced to the domestic state; and they are never found caged by any natives of the Papous, where they are by no means rare, and where their skins form the principal object of commercial exchange between the insular inhabitants and the Chinese Indians or eastern Europeans. Authors (we speak not of those who assert that birds of paradise are nourished by dew, or by the perfume which exhales from fruits and flowers) have assigned different diets to these birds. Some say that they search for fruits and nectarous juices; others that they capture insects, and such small prey. There is truth in both statements, for it seems ascertained that they feed alike on fruits and insects. As to all those anxious interesting cares which precede, accompany, or follow incubation,—these and many other important particulars in their history are still unknown. The natives of New Guinea, in preparing the skins, content themselves by removing the fleshy mass of the body, and cutting off the two wings and legs. They then pass a piece of stick through the mouth downwards to the tail. Few of the museums of Europe contain any other specimens than these mutilated remains, which the gorgeous flowing feathers of the sides render still worthy of admiration, however unfit to convey a true idea of the natural state. Insessores.

We shall next extract some interesting information from a work by M. Lesson, one of the few European naturalists who have had an opportunity of beholding these extraordinary creatures in their native haunts. "Les paradisiers ou du moins l'éméraude, seule espèce sur laquelle nous possédons des renseignemens authentiques, vivent en bandes dans les vastes forêts du pays des Papous, group d'îles situées sous l'équateur, et qui se compose des îles Arou, de Waigiou, et de la grande terre nommée Nouvelle-Guinée. Ces sont des oiseaux de passage qui changent de district suivant les moussons. Les femelles se réunissent en troupes, s'assemblent sur les sommités des plus grands arbres des forêts, crient toutes à la fois pour appeler les mâles. Ceux-ci sont toujours solitaires au milieu d'une quinzaine de femelles qui composent leur sérail, à la manière des gallinacées.

"J'extrairai de mon journal inédit les détails suivans, relatifs aux oiseaux de paradis: ils ont été écrits sur les lieux. *Journal Ms.*, t. vi. p. 19 et suiv. Les *oiseaux de paradis*, à l'exception de deux espèces, nous étaient apportés par les Papous, ce qui établit entre eux et nous un commerce actif d'échange. Je me procurai l'éméraude, le manucode, le loriot paradis orangé, le sifilet, le superbe, les épimaques proméfils, et à paremens frisés, le magnifique, et le rouge. La quantité que les naturels de ces contrées apportaient à bord de la corvette la *Coquille* doit faire supposer que ces oiseaux, si estimés en Europe, y sont singulièrement multipliés. Le manucode se présenta deux fois dans nos chasses, et nous tuâmes le mâle et la femelle. Cette espèce paraît monogame, ou peut-être n'est elle isolée par paires qu'au moment de la ponte. Dans les bois cet oiseau n'a point d'éclat; son plumage rouge de feu ne le décèle point, et sa femelle n'a que des teintes ternes. Il aime à se tenir sur les arbres de teck, dont le large feuillage l'abrite, et dont le petit fruit forme sa nourriture. Il a l'iris brun, et les pieds d'un bleu d'azur très tendre. Les Papous le nomment *saya*. Dès les premiers jours de notre arrivée sur cette terre de promission (la Nouvelle-Guinée) pour le naturaliste, je fus à la chasse. A peine avais-je fait quelques centaines de pas dans ces vieilles forêts, filles du temps, dont la sombre profondeur est peut-être le plus magnifique et le plus pompeux spectacle que j'aie jamais vu, qu'un oiseau de paradis frappa mes regards; il volait avec grâce et par ondulations; les plumes de ses flancs formaient un panache gracieux et aérien, qui, sans hyperbole, ne ressemblait pas mal à un brillant météore. Surpris, émerveillé, éprouvant une jouissance inexprimable, je dévorais des yeux ce magnifique oiseau; mais mon trouble fut si grand que j'oubliai de le tirer, et que je ne m'aperçus que j'avais un fusil que lorsqu'il était déjà bien loin. On ne pourrait guère avoir une idée exacte des paradis d'après les peaux que les Papous vendent aux Malais, et qui nous parviennent en Europe. Ces peuples chassèrent primitivement ces oiseaux pour décorer les turbans de leur chefs. Ils les nomment *mambéfore* dans leur langue, et les tuent pendant la nuit, en grimpant le long des arbres où ils se couchent, et les tirant avec des flèches faites exprès et très courtes, qu'ils façonnent avec le rachis des feuilles d'un latanier. Les campongs ou villages de *Mappia* et d'*Emberbakène* sont célèbres par la quantité des oiseaux qu'ils préparent, et tout l'art des habitans se borne à leur arracher les pieds, à les écorcher, à leur fourrer un bâtonnet à travers du corps, et à les dessécher à la fumée. Quelques uns plus adroits, et sollicités par les trafiquans

[1] Shaw's *General Zoology*, vol. vii. p. 482–4.

Insessores. Chinois, les desséchent avec les pieds. Le prix d'un oiseau de paradis chez les Papous de la côte est au moins d'une piastre, et ces peuples préfèrent l'argent à tout autre objet, même à du fer travaillé.

" Nous tuâmes, pendant notre séjour à la Nouvelle-Guinée, une vingtaine de ces oiseaux, que je préparai pour la plupart. Ils appartenaient à diverses personnes de l'expédition, et notamment au capitaine. Je n'en avais point encore, lorsque M. Bérard, lieutenant de vaisseau, zélé pour les collections que je formais en simple particulier, et à mes frais, pour le Muséum, et pour remplir la promesse que j'avais faite au ministère, en m'embarquant, de recueillir les objets d'histoire naturelle, voulut bien m'en remettre un pour la collection. Depuis, j'en achetai un second d'un homme de l'équipage, que je lui payai 150 francs. J'en tuai ensuite un avec un grand nombre de femelles : on les voit au Muséum.

" L'émeraude en vie est de la taille du geai de France ; son bec et ses pieds sont bleuâtres ; l'iris est d'un jaune éclatant ; ses mouvemens sont vifs et agiles ; il ne se perche communément que sur le sommet des plus grands arbres. Lorsqu'il en descend, c'est pour manger les fruits de quelques arbres moyens, ou lorsque le soleil, dans toute sa force, lui fait un besoin de chercher de l'ombrage. Il affectionne certains arbres, et fait retentir les environs de sa voix perçante. Son cri lui devint fatal, parce qu'il nous indiqua les allures de cet oiseau. Nous l'épiâmes, et c'est ainsi que nous parvîmes à en tuer ; car, lorsqu'un paradisier mâle est perché, et qu'il entend bruiser dans le silence de la forêt, il se tait et ne bouge plus. Son cri d'appel est un *voike, voike, voike, voiko*, fortement articulé. La femelle a le même cri, mais elle le pousse d'une manière bien plus faible. Celle-ci, déchue du brillant plumage de son époux n'a que de sombres atours. Nous en rencontrions à chaque arbre des vingtaines réunies, tandis que les mâles, toujours solitaires, n'apparaissaient que rarement.

" C'est au lever du soleil et à son coucher que l'oiseau de paradis va chercher sa nourriture. Dans le milieu du jour, il se tient caché sous le large feuillage du teck, et n'en sort point. Il semble redouter l'action des rayons brûlans de cet astre, et ne point vouloir s'exposer aux atteintes d'un rival. Nous apprîmes, par une longue expérience, à imiter la ruse de ce bel oiseau ; mais le zéle des tueurs de paradisiers était si grand que personne ne voulait tirer sur aucun autre oiseau de peur de les effaroucher, et que, réduit à peu près à mes seules ressources, le tribut que quelques personnes me donnaient de leur chasse fut bien diminué ; plus curieux, dans l'intérêt de la science, d'un petit volatile inédit, que de posséder plus ou moins de dépouilles d'une espèce connue, bien que prisée, je ne guettai des paradis que pendant quelques jours, et tuai d'ailleurs toute espèce qui arrivait à ma portée.

" Pour chasser les oiseaux de paradis, les voyageurs appelés à visiter la Nouvelle-Guinée doivent se rappeler qu'il est nécessaire de partir dès le matin du navire, d'arriver au pied de l'arbre de teck ou du figuier, que ces oiseaux recherchent à cause de leur fruit (notre séjour a eu lieu du 26 Juillet au 9 Août), avant quatre heures et demie du matin, et de rester immobile jusqu'à que quelques mâles, pressés par la faim, viennent sur les branches qu'on aura jugé à distance convenable. Il est indispensable de posséder un fusil à très longue portée, et chargé à gros plombs, car il est fort difficile de tuer roide un *émeraude*, et s'il n'est que blessé, il est bien rare qu'il ne soit pas perdu pour le chasseur, dans des fourrées tellement épaisses, qu'on ne peut y reconnaitre son chemin sans une boussole.

" Le paradisier petit émeraude mange sans doute de plusieurs substances dans son état de liberté. Je puis affirmer qu'il vit de graines de teck, et d'un fruit nommé *amihou*, blanc rosé, de saveur fade et mucilagineuse, de la grosseur d'une petite figue d'Europe, et qui appartient à un arbre du genre *ficus*. Ces fruits plaisent à beaucoup d'oiseaux, car ils sont aussi recherchés par les *calaos*, les *manucodes*, et les *cassicans calibé* et *phonygame*. Insessores.

" J'ai vu deux oiseaux de paradis conservés dans une cage, depuis plus de six mois, par le chef des commerçans Chinois, à Amboine. Ils étaient toujours en mouvement, et on les nourrissait avec du riz bouilli ; mais ils aimaient surtout les cancrelas (*blatta*). Ce Chinois me les fit 500 francs pièce ; alors, sans argent, et n'ayant point de crédit dans cette île, je ne pus réclamer ma solde, et ce fut en vain que j'offris des objets de valeur à ce trafiquant opulent, il fut sourd à mes prières. Pourquoi, sur l'argent que nous possédions à bord, pour frais accidentels, et qu'on a retourné à Paris, ne pas avoir acheté, pour le destiner à la France, un de ces magnifiques oiseaux, qui serait peut-être mort en route, mais dont les habitudes vivaces, et analogues à celles de nos pies, nous donnaient tant de chances de succès ?"[1]

We shall conclude our miscellaneous extracts in illustration of these birds, by a quotation from a recent English writer. The principal object of attraction to strangers at Macao used to be the splendid aviary and gardens of Mr Beale, who, after a residence of forty years in that country, devoted his leisure to the cultivation of many of the most delightful productions of nature, and among these not the least remarkable was the bird of paradise, as thus described by Mr Bennet. " The specimen in the possession of Mr Beale is a fine male, *Paradisea apoda* of Linnæus, the *P. major* of Shaw. He was at the time I beheld him arrayed in his full and splendid plumage ; he is enclosed in a large and roomy cage, so as not by confinement to injure in the slightest degree his delicate and elegant feathers. This beautiful creature has been in Mr Beale's possession nine years, and was originally procured from the island of Bouro (one of the Molucca group), which is situated in about latitude 3° 30′ south, and longitude 126° 30′ east....The neck of this bird is of a beautiful and delicate canary-yellow colour, blending gradually into the fine chocolate colour of the other parts of the body ; the wings are very short, and of a chocolate colour. Underneath them, long, delicate, and gold-coloured feathers proceed from the sides in two beautiful and graceful tufts, extending far beyond the tail, which is also short, of a chocolate colour, with two very long shafts of the same hue proceeding from the uripigium. At the base of the mandibles the delicate plumage has during one time (according as the rays of light are thrown upon it) the appearance of fine black velvet, and at another a very dark green, which contrasts admirably with the bright emerald of the throat....The mandibles are of a light blue, irides bright yellow, and the feet of a lilac tint. This elegant creature has a light, playful, and graceful manner, with an arch and impudent look ; dances about when a visitor approaches the cage, and seems delighted at being made an object of admiration ; its notes are very peculiar, resembling the cawing of the raven, but its tones are by far more varied. During four months of the year, from May to August, it moults. It washes itself regularly twice daily, and after having performed its ablutions, throws its delicate feathers up nearly over the head, the quills of which feathers have a peculiar structure, so as to enable the bird to effect this object. Its food, during confinement, is boiled rice mixed up with soft egg, together with plantains, and living insects of the grasshopper tribe ; these insects, when thrown to him,

[1] *Manuel d'Ornithologie*, t. 1. p. 387.

Insessores. the bird contrives to catch in his beak with great celerity; it will eat insects in a living state, but will not touch them when dead.

"I observed the bird, previously to eating a grasshopper given him in an entire or unmutilated state, place the insect upon the perch, keep it firmly fixed with the claws, and divesting it of the legs, wings, &c. devour it, with the head always placed first.....It rarely alights upon the ground, and so proud is this creature of its elegant dress, that it never permits a soil to remain on it; and it may be frequently seen spreading out its wings and feathers, and regarding its splendid self in every direction, to observe whether it is in an unsullied condition."[1]

Dr Shaw alludes to an instance of the bird of paradise having been brought alive to England. It had, however, entirely lost the beautiful floating feathers which render its body apparently so light and buoyant, and did not long survive its arrival in our murky clime.

Although there are not above seven distinct species of these birds, they have been formed into no less than four separate genera by M. Vieillot. The most anciently known is the kind called in English books the great or common bird of paradise, *l'émeraude* of the French, *P. apoda*, Linn. to which most of the preceding memoranda may apply. (See Plate VIII., figure 6.) It is of a cinnamon colour, the upper part of the head and neck yellow, the front and throat emerald green, or black. It is the male of this species which bears the long, floating, yellow plumes so prized as articles of commerce, with a view to ornament in dress. Although the body is no larger than that of a thrush, the total length is two feet. In the red paradise bird (*P. rubra*) the head and throat are emerald-green, the back and front of the neck orange yellow and velvety, the throat chesnut or cinnamon colour, and the long feathers of the flanks brilliant carmine red. The two peculiar barbless shafts which proceed from the base of the tail, are broad, flattened, twisted, and of a brownish-red colour. These belong to the restricted genus PARADISEA.

The six-shafted paradise bird (*P. sexsetacea*, Shaw,—*P. aurea*, Gmel.) is black, with the throat of golden green, and three prolonged setaceous feathers proceeding from behind each eye, and terminating in a little expanded disk of golden green. It forms the genus PAROTIA of Vieillot. We shall merely add, that *P. superba* constitutes the genus LOPHORINA,—*P. regia* that called CICINNURUS,—and *P. nigra*, Gmel., another named ASTRAPIA. The whole are figured by Buffon, Vaillant, or Vieillot, and their singular forms, gorgeous colouring, and exquisite structure of plumage, render them deserving of the most attentive consideration on the part of all admirers of nature.

TRIBE 4TH.—TENUIROSTRES.

Baron Cuvier here places a variety of generic groups which agree chiefly in possessing a slender lengthened bill, sometimes straight, sometimes considerably curved. According to the structure of the tongue, which in several genera is not yet distinctly known, they feed either on insects or the nectarous juices of fruits and flowers,—a few, such as the humming-birds, combining both these habits.

In the genus SITTA the bill is straight, pointed, compressed at the extremity, and the tongue short and corneous. The species called *nut-hatches* climb along the bark of trees with extraordinary facility, not only upwards, like the woodpeckers, but downwards, and in all directions. The European species (*S. Europea*), though a constant resident in Britain, is rather rare in most localities. It breeds in hollow trees, not seldom using the deserted habitation of a woodpecker, the opening into which it contracts by means of a wall of clay. The female sits very close during incubation, and instead of flying off when approached, she will utter a hissing sound, and make a show of striking at the intruder with her bill and wings. Sir W. Jardine some years ago enjoyed an opportunity of observing a brood which had been taken young. They became remarkably tame, and when released from their cage, would run over their owner in all directions, poking into seams and pockets, as if in search of food upon some goodly tree, and uttering from time to time a low and plaintive cry. In climbing, they rest much upon the tarsus, but never use the tail. Several true nut-hatches occur in North America, but Pennant erred in supposing that the European species was likewise indigenous to the new world. Insessores

In the genus XENOPS of Illiger, the bill is rather more compressed, and the under ridge more convex, while in ANABATES of Temm. it is the upper ridge which increases in convexity, so as to approach to that of the thrushes; but the tail in some of the species is long and wedge-shaped, and exhibits a worn appearance, as if it were occasionally used in climbing.

In the genus SYNALLAXIS, Vieil., the bill is straight, not much lengthened, considerably compressed, slender and pointed, and the tail is generally long and acuminate. (See Plate VIII., figure 7.) We know little of the habits of these birds, except that they are insectivorous, and dwell in forests. Most of the species are from South America, and to these it is probable that the generic term should be restricted.

The old genus CERTHIA of Linnæus was characterized by an arched bill, but the species possessed but little else in common, and have been therefore formed into several minor groups. The true or restricted creepers (CERTHIA, Cuv.), so called from their habit of running round the trunks of trees, have the bill of medium length, curved, compressed, slender, sharp pointed. The tail is wedge-shaped, and composed of stiff, deflected feathers. Our well-known British species (*C. familiaris*) is the only example of the genus found in Europe, and it is in fact doubtful whether there is any other elsewhere. The North American creeper seems identical, but the numerous other birds described as creepers do not belong to the genus Certhia. The solitary type alluded to is a retired inhabitant of the woods, in no way conspicuous in colour, though pleasingly mottled above with black, brown, and grayish white; and being of small size, and seldom showing itself in open places, is deemed rarer than it really is. Though of a somewhat lengthened form, it is probably, with the exception of the golden-crested wren, the smallest bodied British bird. It is said to feed entirely upon insects, although as a winter resident in many frost-bound regions, we shall not aver that it never swallows seeds. It builds in the hollows of trees, and may be often seen during the delightful autumn, when the rustling woods are fragrant with fallen leaves, flitting from the top of one trunk to the bottom of another, which it ascends by a kind of spiral progression, and then darting downwards to a neighbouring tree, it thus busily pursues from time to time its interrupted flight. This bird chiefly shows itself in our shrubberies and wooded pleasure-grounds in winter.

In the genus DENDROCOLAPTES, Hermann, the tail resembles that of the preceding, but the bill is much stronger, and enlarged at the base. In certain species it is greatly curved. (Plate VIII., figure 9.) These birds are American, and are usually characterized by a reddish plumage. In TICHODROMA, Illiger, the tail does not present a worn appearance at the point, although the best known, if not the only species, runs up rocks with great agility. The bill is long, slender, triangular, and depressed at the base.

[1] *Wanderings in New South Wales*, &c. vol. ii.

Insessores.

The European species, called by us the wall-creeper (*T. phœnicoptera*, Temm.,—*Certhia muraria*, Gmel.), inhabits the southern countries of Europe, where it dwells among lofty and precipitous rocks. It is well known among the Swiss Alps, and the mountainous parts of Spain and Italy, where it is said to prey much on spiders and their eggs.

In the genus NECTARINIA of Illiger, the bill is arched, pointed, and compressed, resembling that of the creepers, with which the species were so long conjoined; but they do not climb, and their habits, if the name is properly applied, are not so much insectivorous as honey-sucking. They are all exotic. The term *guit-guit* is given by the French to certain small species, of which the plumage of the males is very rich and lustrous. Their tongue is bifid and filamentary. Such are *Certhia cyanea, cerulea*, &c. Some species of larger size and less adorned plumage, and of which the tongue is short and cartilaginous, have been separated from the others. Such is a South American species, the *Merops rufus* of Gmelin, as large as a nightingale, of a reddish colour above, the throat whitish. It constructs a covered nest, and serves as the type of Temminck's genus OPETIORHYNCHUS.[1]

The genus DICÆUM of Cuv. has the bill longer than the head, sharp, curved, depressed, and broadened at the base. The species are of small size, and usually ornamented with portions of scarlet. They are natives of the East Indies. In MELITHREPTUS of Vieillot, the bill is extremely long, and curved almost into a semicircle. Of this form the hook-billed creeper, *Certhia vestiaria*, Shaw, affords a good example. (Plate IX., figure 2.) It is a native of the Sandwich Islands, where it is much valued on account of its plumage, which affords the principal material in the formation of those gorgeous scarlet mantles worn by chiefs and persons of distinction.

The *souimangas* (a Madagascar name, signifying sugar eaters, genus CINNYRIS, Cuv.) have the bill long, slender, and finely toothed along the edges. The tongue is capable of considerable extension, and terminates in a small bifurcation. The species are widely dispersed over all the southern regions of the old world (Africa, the Indian Archipelago, &c.), and seem in those countries to represent the beautiful humming-birds of the western world. Indeed these tribes greatly resemble each other both in form and habits. The souimangas are subject to a double moult, which occasions a considerable diversity in the plumage even of the same species, according to the season of the year; and hence our knowledge of this, as of several other sumptuous groups, though sufficiently voluminous, is probably not yet remarkable for its accuracy. Several splendid works, however, have been devoted, either in whole or in part, to its illustration.[2] The nuptial plumage is remarkable for its golden lustre, and the richness and variety of its innumerable iridescent hues; but after the termination of the breeding season, a much more humble garb is assumed, and many a *bizarre* appearance is presented by the intermediate links of that changeable costume which connects the holiday-suit of spring with the more quaker-like attire of autumn. Hence the difficulty of distinguishing in many birds, between a specific difference and an individual variation, more especially where foreign species are concerned; for in such instances we have seldom a prolonged opportunity of verifying our observations on external characters, by an examination of natural habits and instinctive modes of life. Yet it is only by ascertaining the uniformity presented by all these circumstances in a variety of individuals, that we are enabled to trace out the exact limits of specific identity. Several species of Cinnyris occur in India, but the greater proportion are of African origin, and may be said to form the most signal and admired feature in the Ornithology of that country.

Insessores.

In the greater number the tail is equal. Of these we may name the superb creeper (*C. superba*), described and figured in the magificent work of M. Vieillot. Its length is six inches; the crown of the head, upper part of the neck, smaller wing-coverts, back, and rump, are bright-greenish gold; across the upper part of the breast runs a bar of bright gilded yellow, beneath which the whole under parts are deep brownish crimson; the wings and tail are blackish brown, the legs are also brown, the bill is black. This beautiful species was discovered at Malimba, in Africa, by M. Perrein. Another highly adorned species, such "as limners love to paint, and ladies to look upon," is the *Certhia splendida* of Shaw (*C. afra* and *lotenia*, Linn. ?). It usually occurs in woody places, and, in addition to its splendid plumage, is said to be worthy of admiration for its musical powers,—its song being by some esteemed equal to that of the nightingale. The spotted breasted Cinnyris (*C. maculata*) also dwells in the forests of Malimba, and frequently approaches the habitations of the natives, allured by the flowers of the Cytisus cajan, commonly called the congo pea, which, according to Dr Shaw, is much cultivated by the negroes.

In some of these birds the central feathers of the tail are lengthened in the males. Such is *C. violacea*, a Cape species, which likewise dwells in woods, and is said to build a nest of a singularly elegant construction. In a few the bill is almost straight, as in *C. rectirostris*, Vieillot. Our restricted limits will not admit of our expatiating on this delightful group.

The genus ARACHNOTHERA of Temm. has the long arcuated bill of the souimangas, but it is of stronger structure, and wants the dentations, and the tongue is short and cartilaginous. The species (such as *A. longirostra* and *inornata*, Temm. *Pl. Col.* 84, figs. 1 and 2), so far as yet known, inhabit the Indian islands, and prey on spiders.

The genus TROCHILUS, Linn., contains the true humming-birds, a numerous group of fairy and fantastic forms, which inhabit both continents of America, and some neighbouring islands, but are altogether unknown in the ancient world. The bill is long and slender, but in its range throughout the entire species exhibits considerable modification, being in some nearly straight, in others curved, and in a few turned upwards. Such as are characterized by an almost straight bill constitute the genus ORNISMYA, Lesson (*Orthorhynchus*, Lacepede), Plate IX., figure 1; while those in which it is more or less bent remain under the ancient name of TROCHILUS, *Ibid.* fig. 6. The tongue is long and extensile, and is usually described as being composed of two muscular tubes united for the greater part of their length, and broadening towards the point into a spoon-like portion. Sir W. Jardine, on relaxing a specimen of *T. moschitus*, observed the appearance of a fimbriated opening at the tip, the outer margin of each division being beset with recurved, sharp-pointed, pliable spines, while in all that Mr Swainson examined the two filaments were perfectly flat. Their feet are extremely small, their wings long and narrow, their tails comparatively broad,—whilst their shortened humerus and very large unnotched

[1] The generic name of *Nectarinia* was bestowed by Illiger upon those foreign creepers known by the terms *guit-guits* and *souimangas*, but it has been applied more exclusively by Cuvier to the former, and by Temminck to the latter. The souimangas, on the other hand, fall into Cuvier's genus *Cinnyris*, while the guit-guits are placed in the genus *Cæreba* by Temm. These transpositions, as we have already remarked, are extremely perplexing.

[2] Vaillant, *Hist. Nat. des Oiseaux d'Afrique*, 5 vols in 4to, 1799, and subsequent years,—and Audebert, *Oiseaux dorès, ou à reflets métalliques*, 2 vols. fol. Paris, 1802. A continuation of the latter work has been published by M. Vieillot.

Insessores. sternum exhibit osteological features in relation to the power of flight resembling those of swifts. The beauty of their plumage, if equalled, is certainly unsurpassed among the feathered tribes.

Humming-birds, in general, may be said to inhabit chiefly the intra-tropical regions of America, including the West Indies; but that they are capable of sustaining a considerable reduction of temperature, and of spreading themselves into comparatively rigorous climes, is evident from the observations of Captain King, who in his survey of the southern coasts met with numerous examples of these diminutive creatures flying about in a snow-storm near the Straits of Magellan, and discovered two species in the remote island of Juan Fernandez. Two other hardy species had been long known to migrate during summer far into the interior of North America, viz. the ruff-necked humming-bird (*T. rufus*), discovered during Cook's voyage in Nootka Sound, and since traced by Kotzebue to the 61st degree of north latitude, along the western shores; and the ruby-throated humming-bird (*T. colubris*), which was found breeding by Mr Drummond near the sources of the Elk River, and is known to reach at least as far north as the fifty-seventh parallel. Mr Bullock also discovered several species at a high elevation, and of course a coolish temperature, on the lofty table-lands of Mexico, and in woods in the vicinity of the snowy mountains of Orizaba. The best and most ample history of these "feathered gems" may be gathered from the pages of Wilson and Audubon, while the superb adornment of their beautifully pencilled plumage, so rich in its varied combination of lustrous green and gold, may be studied with advantage in the sumptuous pages of M. Lesson.[1] They are of a most lively and active disposition, almost perpetually upon the wing, and darting from flower to flower with the busy rapidity rather of a bee than a bird. In the uncultivated districts of the country they inhabit the forests, but in peopled regions they flock without fear into the gardens, poising themselves in the air, while they thrust their long extensile tongues into every flower in search of food. According to Bullock, they will remain suspended in a space so small that they have scarcely room to move their wings, and the humming noise which they produce proceeds entirely from the prodigious velocity with which they vibrate these tiny organs, by means of which they will remain in the air almost motionless for hours together. An older writer, Fermin, a physician of Surinam, compares this action to that of the bee-like flies which in still and sultry weather we often see hovering in the vicinity of still waters; and Wilson says, that when a humming-bird arrives before a thicket of trumpet-flowers in bloom, he suspends himself so steadily that his wings become "invisible, or like a mist." They often enter windows, and after examining any fresh bouquets with which fair hands may have decked the table, they will dart like sun-beams out by an opposite door or window. During the breeding season they become jealous of encroachment, and exhibit great boldness in defence of their supposed rights. When any one approaches their nest, they will dart around with a humming noise, frequently passing within a few inches of the intruder's head. A small species called the Mexican star (*T. cyanopogon*) is described by Mr Bullock as exhibiting great intrepidity while under the influence of anger. It will attack the eyes of the larger birds, striking at them with its sharp, needle-like bill; and when invaded by one of its own kind during the breeding season, their mutual wrath becomes immeasurable, their throats swell, their crests, tails, and wings expand, and they fight in the air till one or other falls exhausted to the ground. Indeed old Fernando Oviedo gives a still more alarming statement of their fiery temper. "When they see a man climb ye tree where they have their nests, they flee at his face, and stryke him in the eyes, commying, goying, and returnyng with such swiftness, that no man woulde ryghtly believe it that hath not seen it."[2] Insessores.

Although humming-birds may frequently suck the juices of flowers, those naturalists err who allege that they support themselves exclusively on that natural nectar. "For myself," says Wilson, "I can speak decisively on the subject: I have seen the humming-bird for half an hour at a time darting at those little groups of insects that dance in the air in a fine summer evening, retiring to an adjoining twig to rest, and renewing the attack with a dexterity that sets all our other fly-catchers at defiance." Mr Bullock thinks it probable that all the species eat insects, and he had repeated ocular proof that many of them feed on flies, which they both caught themselves, and used to *steal* from spiders' webs. It was only the smaller kinds, however, that they dared to molest, for the stronger spiders showed fight, on which the besiegers would shoot off with the rapidity of a sun-beam, and could scarcely be discovered but by the luminous glow of their refulgent colours. It may easily be conceived that creatures of such resplendent plumage, in spite of their irascible temper and pugnacious habits, are universal favourites wherever they appear; and that in "the sweet serenity of a summer morning," their visits to the dewy flower-beds of a cottage dwelling are surely welcomed with delight.

When morning dawns, and the blest sun again
Lifts his red glories from the eastern main,
Then through the woodbines, wet with glittering dews,
The flower-fed humming-bird his round pursues;
Sips with inserted bill the honey'd blooms,
And chirps his gratitude as round he roams;
While richest roses, though in crimson drest,
Shrink from the splendour of his gorgeous breast.
What heavenly tints in mingling radiance fly!
Each rapid movement gives a different dye;
Like scales of burnished gold they dazzling show,
Now sink to shade—now like a furnace glow!

In the summer of 1803 a nest of young humming-birds was brought to Alexander Wilson. They were nearly fit to fly; in fact, one of them did fly out of the window the same evening, and falling against a wall, was killed upon the spot. The other refused food, and in consequence of this foolish obstinacy its life next morning was nearly extinct. A lady in the house undertook to be its nurse, and placing it in her bosom, it immediately began to revive, which showed its good taste and natural sense of comfort. She then kindly dissolved a little sugar in her mouth, and thrusting its bill into the same, the creature sucked with great avidity. In this manner it was brought up until fit for the cage. Wilson kept it for three months afterwards, supplying it constantly with loaf-sugar dissolved in water, which it preferred to honey and water. He also gave it fresh flowers every morning, sprinkled with the sugary liquid. It appeared quite gay, active, and full of spirit, hovering from flower to flower as if in its native wilds (alas! it still was caged), and always expressed by its motions and chirping the greatest pleasure at the sight of every fresh supply of flowers. "Numbers of people," says our author, "visited it from motives of curiosity, and I took every precaution to preserve it if possible through the winter. Unfortunately, however, by some means it got at large, and, flying about the room, so injured itself that it soon after died."

Most of the preceding notices apply to the ruby-throated humming-bird (*T. colubris*, Linn.), the species of which

[1] *Histoire Naturelle des Oiseaux Mouches;—Hist. Nat. des Colibris;—Hist. Nat. des Trochilidés.*
[2] *History of the West Indies*, translated by Richard Eden, p. 199.

Insessores. the particular habits and general economy have been the most minutely studied. It sometimes makes its appearance in Louisiana as early as the 10th of March, and shows itself some weeks later in the northern states, varying not only with the latitude, but the temperature of each season. Its nest is described by Mr Audubon as being of the most delicate nature, the external parts formed of a light-gray lichen found on the branches of trees, or on decayed fence-rails, and so neatly arranged round the whole nest, as well as to some distance from the spot to which it is attached, as to seem part of the branch or stem. These little pieces of lichen, he and others allege, are glued together with the saliva of the bird; but whether this fact has been proved by observation, or is only a natural inference from the actual appearance of agglutination, we cannot say. The next coating, however, consists of a cottony substance, and the innermost of all of silky fibres obtained from various plants, and extremely soft and delicate. In this delightful little bed the female lays only two eggs, of an almost oval form, and colour of pure white.[1] Not more than ten days are required for hatching; the young are ready to fly in seven or eight days; they are fed or cherished by the parents for nearly another week; and Mr Audubon is of opinion that they are no sooner able to provide for themselves than they associate with other broods, and perform their migrations apart from the old birds, as he has sometimes observed twenty or thirty young humming-birds resorting to a group of trumpet-flowers when not a single adult male was to be seen.[2] The migration of birds, as Dr Richardson has well observed, has in all ages been an object of pleasing speculation to the philosopher; but in no instance does it appear more wonderful than when contemplated in relation to these tiny tribes. The lofty and sustained flight of the eagle and albatross seems only commensurate with their gigantic size, and the irresistible sweeping of their mighty pinions; "but how is our admiration of the ways of Providence increased, when we find that one of the least of its class, clothed in the most delicate and brilliant plumage, and apparently more fitted to flutter about in a conservatory than to brave the fury of the blast, should yield to few birds in the extent of its migrations."[3]

The only instance with which we are acquainted of a humming-bird having been brought alive to England, is that mentioned by Latham. A young gentleman, a few days before sailing from Jamaica, observed a female of *Trochilus mango* sitting on her eggs. He secured the bird, cut off the twig, and brought the whole on board his vessel. The mother was fed with honey and water, and during the voyage hatched two young ones, which surviving their parent, were landed in England and lived for some time in the possession of Lady Hammond, from whose mouth they readily sipped nectar. The longest survivor, however, died in about two months after its arrival. These frail creatures are in fact far too impatient of continuous cold to endure the climate of Britain during winter. We shall conclude by observing, that the species are very numerous, and, like the generality of extensive groups, have been of late partitioned into many minor genera by M. Lesson, and others who have devoted themselves to their consideration. The range of size, as well as of character, is considerable,—*Trochilus minimus*, which is no larger than an able-bodied bee, is the least of all the feathered race,—while *Trochilus gigas*, a "triton 'mong the minnows," is the largest of humming-birds, and almost equals the dimensions of a swallow.

In proceeding with our exposition of the tenuirostral tribes, we now approach the *Hoopoes*, in close approximation to which is placed the genus FREGILUS of Cuvier, containing only a single European species, the *Corvus graculus*, or red-legged crow of British writers, which we have already briefly noticed as a *Pyrrhocorax*. It is in truth so nearly allied to the Alpine crow (*C. pyrrhocorax*), or *choucard des Alpes*, both in structure and habits, and is so often seen in company with that species, that wherever the one may be placed, the other should not be far distant. M. Temminck, indeed, places them in the same genus, although the bill of the red-legged bird (or Cornish chough) is longer than the head, more subulate and slender at the point, and without any notch. Cuvier regards the *Corvus affinis* of Latham, and another species from New Holland, as both belonging to the genus FREGILUS. Insessores.

The true hoopoes (genus UPUPA) are all distinguished by a crest upon the head, composed of a double row of lengthened plumes, and capable of being raised at pleasure. The only European species (*U. epops*, Linn. Plate IX., figure 3) is a summer bird of passage on the Continent, where it travels northward even as far as Sweden. It never breeds in Britain, though it sometimes accidentally occurs there. We had one sent us a few years ago from the county of Fife. This bird is called *bubbola* by the Italians, most probably from its peculiar cry. It keeps itself concealed among the trees; but is constantly heard repeating the syllable *bu, bu, bu, bu, bu*, with such a strong sonorous voice, that it may be heard at a great distance. Its song properly so called is only uttered during the honey-moon. Although the hoopoe lives and builds in woods, it may be often seen, in search of insect food, in fields and pastures. The nest is generally placed either in the natural hollow of a tree, or in the deserted excavation of a woodpecker. It is composed outwardly of feathers, and is lined with the hair of cows and horses. The eggs are grayish white, finely spotted with brown. This bird is very common in Egypt. A nearly allied species (*U. Capensis*) is found at the Cape, and occurs also in the East Indies; but we presume M. Savi is in error when he says the genus is likewise known in America.

The genus PROMEROPS of Brisson has also an elongated slender bill, finely pointed, laterally compressed, somewhat convex above, with the nostrils open and cleft longitudinally. The tail is very long and graduated, and the tongue is extensile and bifurcated, so that the species are able to absorb the nectarous juices of flowers. The title seems now restricted to the African species, of which the only one distinctly known is the Cape promerops (*P. Capensis, Merops caffer*, Gm.), of a grayish brown above, with a white throat, bordered by two dark lines, the breast reddish, the abdomen yellow. The tail is of great length during the completed plumage; but the long, ribbon-like feathers are often absent, which greatly alters the external character of the bird. (See Plate IX., figure 5.)

In the magnificent and somewhat disputed genus EPIMACHUS, Cuv., the bill, though more robust in some of the species, resembles that of the two preceding genera; but the base, or region of the nostrils, is beset with short, rounded, scale-like feathers, after the manner of the birds of paradise, which they somewhat resemble, moreover, in the great extension of certain portions of their plumage. They are also native to the same countries. The *Epimachus magnificus* has the general plumage of a rich velvet black, the head and throat lustrous, with changing tints of green and blue. The tail is of ordinary length and structure, but the sides are singularly ornamented by long extended filamentous feathers. (See Plate IX., figure 7.) The female is much less adorned, being, according to M.

[1] Dr Richardson describes the eggs as of "a reddish white colour, and obtuse at both ends."

[2] *Ornithological Biography*, vol. i. p. 251.

[3] *Fauna Boreali-Americana*, part ii. p. 323.

Insessores. Lesson, reddish above and gray below, streaked with brown. The *Epimachus superbus* is likewise of a velvet black, glossed in various parts with golden green and purple, the flank feathers greatly developed, and terminated by a brilliant edging. The tail is of such enormous length (Plate IX., figure 4) that the total extent of this species is nearly four feet. The female (*Upupa fusca* of Gmelin ?) is described as reddish on the wings and tail, the body of a mingled black and brown. The two preceding kinds inhabit New Guinea. The *Paradisea alba* of the older systems is by some referred to our present genus, which has also been made to contain a beautiful New Holland species, known to the natives by the name of rifle-bird, and described by Mr Swainson under the title of *Ptilorus paradiseus*. It is the *Epim. regius* of Lesson and Garnot,[1] and was previously figured by Mr Wilson as *Epim. Brisbanii*, in honour of General Sir Thomas Brisbane, by whom it is believed to have been first transmitted to this country.[2] If not a true Epimachus, it certainly greatly resembles that genus, having the form and colouring of *E. magnificus*, and the same tendency (though less strongly developed) to an elongation of the lateral plumes. The obscure black and brown plumage of the female likewise corresponds to what M. Lesson regards as the sexual distinctions of the other species. We have had recent information, which confirms our former views, that it is not of honey-sucking propensities. It rather exhibits a tendency to scansorial habits; and in its search for insects its bill may be heard from some distance tapping the bark, like that of a woodpecker.

All the preceding groups of the PASSERINE ORDER belong to Cuvier's first primary division, which, as we said at starting (see page 747), is characterized by never having the outer united to the inner toe by more than the length of one or two phalanges.

Those which follow, on the contrary, forming the second and much less numerous primary division of our present order, have the outer toe almost as long as the middle one, and united to it as far as the base of the terminal articulation. Such a principle of division might, *a priori*, be inferred to lead to some serious mal-arrangement of the groups; for it is extremely unlikely that so trifling a character should be found in uniform accordance with other and more influential attributes, and the slightest study or most superficial inspection of this the *Syndactylous Division* of Baron Cuvier's passerine order will suffice to show that the said division is in many points extremely heterogeneous and unnatural. To prove this to the satisfaction of any one at all conversant with the character of the prevailing forms in Ornithology, it will suffice merely to enumerate its component parts, viz. the bee-eaters (*Merops*), the motmots (*Prionites*), the king-fishers (*Alcedo*), the todies (*Todus*), and the horn-bills (*Buceros*). It is indeed surprising that any one so gifted with the power of philosophical observation, so qualified by his profound acquaintance with comparative anatomy to trace the natural relations of living creatures, and so signally successful in his usual generalizations, should either have brought together, or permitted to remain in juxtaposition, so discordant a group. The regulating character supposed to be competent to amalgamate these discordant materials is alleged to consist simply in the close adherence of the outer and middle toe throughout a considerable portion of their length, that is, as far as the penultimate joints. Now, that this character by itself is of no avail in the formation of natural groups, is evident from two considerations:—1*st*, From its being found in numerous genera, which are admitted to bear no affinity to each other;—2*dly*, from its being absent in some of the component members of a natural family, and present in others. We may illustrate this by an example. In the South American genus *Ampelis* there are genuine specice, in some of which the outer and middle toes are united, while in others they are free. This is well seen in the beautiful *Ampelis carnifex*, in which these parts are joined together, while in the closely allied species *A. pompadoura* they are disunited. Having called the reader's attention to this inconsistency, we shall proceed to a brief sketch of the different generic groups above named. Insessores

In the beautiful genus MEROPS, Linn., the bill is elongated, somewhat triangular at the base, slightly arched, sharp pointed. The wings are long, and narrow at the extremity. The feet are short. The flight of these birds, commonly called bee-eaters, is easy and buoyant, resembling that of the swallow. The species are numerous in Africa and the East; but only one is accustomed to show itself in Europe, the *Merops apiaster*, or *common* bee-eater of English writers (to whom, however, it is one of the rarest of the feathered race), an elegantly-formed and richly-plumaged bird (Plate X., figure 2). It arrives in the southern countries of the Continent in March, and departs in September. It flies in flocks, usually at a considerable elevation, and utters with hoarse and guttural voice, in startling disaccordance with its slender aspect, a continual cry of *gra, gra, gra*. It builds in deep horizontal holes in sandy banks, which it excavates in whole or in part, working vigorously with feet and bill, and kicking out the dry earth behind it with great dexterity. It lays six or seven eggs, white, lucid, and almost spherical. When the young are partly fledged, but not yet fit to fly, they creep to the mouth of their holes, where they seem to enjoy the happy summer light and genial sunshine; but on the least alarm they trundle stern foremost into their inner chambers, where they lie concealed until tranquillity again prevails. So accustomed do they seem indeed to this peculiar movement, that when taken from the nest, and placed in any more exposed position, they seek to escape by running backwards. In fact, for a time they seem unable to walk in any other direction. All these birds are exclusively insectivorous, and prey almost entirely on the hymenopterous tribes. Although they often take their food upon the wing, they also gather it from the ground; and whenever they espy the small hole which leads into the nest of wasp or bembex, they place themselves close beside it, and snap up the industrious tenants on their exit or arrival. The Italian contadini regard the cry of the bee-eater as a sign of rain when they hear it uttered from a great height. The appearance of this beautiful bird in England is accidental. We may add, that none of the species occurs in America.

In the genus PRIONITES, Illiger, the feet and form are similar, but the bill is much stronger than in the preceding, the margins of both mandibles are crenulated (see Plate X., figure 3), and the tongue is feathered. These birds are natives of South America. The plumage of their head is loose, like that of our common jay, the tail is long and graduated, and in adult birds the two central feathers are often bare or barbless for a space not far from the extremity. They prey on insects, occasionally attack small birds, and build their nests in the hollows of trees. Example, the blue-crowned motmot, *Ramphastos momota*, Gmelin.

The genus ALCEDO, containing the king-fishers, has the legs still shorter than the bee-eaters, and the bill long, straight, angular, and pointed (Plate X., figures 1 and 4). As originally constituted, it contained a numerous assemblage of species from various countries of the world, of shape

[1] *Voyage de Duperrey*, pl. xxviii.

[2] *Illustrations of Zoology*, vol. i. pl. xi.

Insessores. and proportions rather awkward than elegant, but almost all remarkable for great splendour of plumage. The size and length of the bill are usually disproportioned to the body, and the feet and legs seem of a diminutive and apparently inconvenient form; but the shining silky lustre of the feathers, and their rich and infinitely varied hues of the most brilliant green and blue, contrasted with different shades of orange, black, and brown, render the genus one of the most showy and attractive within the entire range of the ornithological system. The *Alcedo ispida* (our common king-fisher) is the only species which occurs in Europe, and it yields to few of its brethren in its lustrous beauty. It is one of the rarest, and certainly the most highly adorned, of all our resident species. It haunts the banks of lakes and rivers, building in hollows near their margin, and preys chiefly on small fish, on which it darts with the rapidity of an arrow, plunging its little gem-like body for one flashing moment in the crystal stream.

Certain modifications observable in the form of the bill, and accompanied, as usual, by a corresponding change of habits, have induced the division of the original genus. For example, we owe to Dr Leach the formation of the genus DACELO, of which the type is the giant king-fisher of New Holland (*A. gigantea* of Latham). The bill is very strong, curved at the extremity, and bulged beneath. These species (called *martin-chasseurs* by the French) inhabit forests, and build their nests, not in the excavated banks of rivers, but in the hollows of lofty trees; whereas the true king-fishers (*martin-pecheurs*) are never found at any distance from the "pure element of waters." The former also feed on insects rather than fish, and, the larger kind especially, are clothed in a dingier and less adorned plumage.

The one above alluded to (*D. gigantea*) is described by Mr Bennet as well known to the colonists of New South Wales by the name of laughing or feathered jackass,—a designation which occasioned a lady at home to declare, that of all the wonderful productions of Australia, she thought nothing could equal the "feathered donkey." Its peculiar gurgling laugh, commencing in a low and gradually rising to a louder tone, is often heard by travellers, proceeding from the branch of some lofty tree, where the bird is watching for its prey. It is said that one seldom laughs without being accompanied by another, apparently anxious to join in a duet. This bird is respected by Australian gardeners for destroying grubs, &c.; and Mr Bennet reports, that it also deserves protection on account of its devouring mice and venomous reptiles. "A gentleman told me he was perfectly aware of the bird destroying snakes, as he had often seen them carry the reptiles to a tree, and break their heads to pieces with their sharp, strong beaks." "One of these birds, seen upon the branch of a tree near a river, looking so stupid, and nodding as if asleep, was shot, and it was then found that this peculiar manner proceeded from its having swallowed a small snake, which had got into the stomach, throat, and bill, but had not yet accommodated itself in the former cavity."[1]

A rare and remarkable species, from the Moluccas, with a shorter bill than usual, and a much longer tail, sometimes called the ternate king-fisher (*A. dea*, Linn.), forms the genus TANYSIPTERA of Mr Vigors,—while a few small species which either want the inner toe, or possess it in a very rudimentary state, constitute the genus CEYX of Lacepede. The latter occur in India. Example, *A. tribachys*, Shaw. (Plate X., figures 5 and 11.)

The genus TODUS contains some small American birds, supposed to resemble the king-fishers in their general form, their feet, and lengthened bills; but the latter organ is horizontally depressed, and obtuse at the extremity, the tarsi are more elevated, and the tail shorter. Their habits are insectivorous, and the species, very few in number as the group is now restricted, are by most Ornithologists arranged among the *Muscicapidæ*, near the genera *Platyrhynchus* and *Muscipeta*. The best-known, if not the only species, is the green tody (*T. viridis*, Linn.). It is found in the Antilles, and some of the equatorial regions of South America, where it hunts insects like a fly-catcher, but builds in holes in banks, after the manner of a king-fisher. Its nest is placed in a little chamber at the termination of a tortuous gallery, and both sexes are remarkable for their strong attachment to their young. This delightful bird is named ground-parrakeet by the Creoles of St Domingo. Though not very rare, it usually dwells in wild and solitary places, which is probably the reason of its being by no means frequent in the collections of Europe. The male utters an agreeable song during the pairing season, but at other times the green tody is a very silent bird. Its flight is straight and rapid, and it sits at times both on stones and trees. (Plate X., figures 6, 7, and 9.) Insessores.

The genus BUCEROS, which includes the calaos or horn-bills, is the last of the great passerine order in the arrangement of Baron Cuvier (Plate X., figures 8 and 10). It certainly differs greatly from those near which he makes it stand, nor does it amalgamate much better with its neighbours in more recent systems. The species are natives of Africa and India, and are characterized by their enormous bills, toothed along their edges, and frequently surmounted by an additional horny structure, which bestows on them a very striking and peculiar physiognomy. These excrescences vary considerably with the age of the individual, and are scarcely perceptible in the young birds. The horn-bills may be said to resemble the toucans in their heads, the crows in their general habits, and the syndactylous tribes in the form of their feet. Their tongue is very small. These birds may be regarded as omnivorous, as they feed indifferently on fruits, mice, small birds, reptiles, and even carcasses. They exhibit an awkward and uncommon aspect while in the act of flying, in consequence of the great size of their beaks and lengthened tails, and altogether their appearance is extremely uncouth. Perhaps one of the most singular features in their economy consists in their feeding greedily, and without injury, on the seeds of *nux vomica*.[2]

The African horn-bill (*B. Africanus*) is entirely black, and nearly as large as a turkey. The crowned species (*B. coronatus*) is a much smaller bird, scarcely equalling the size of a magpie. Le Vaillant saw a flock of more than five hundred of these birds, in company with crows and vultures, preying on the remains of slaughtered elephants. It is figured by Mr Swainson in the third volume of the first series of his beautiful Illustrations. A large and remarkable Indian species was several years ago described by Mr Hodgson. It measures four feet five inches from tip to tip of the wings, and is three feet six inches in length. Its body exceeds that of the largest raven, but is very lean and incompact. It is believed to feed chiefly on fruits, although it will seize upon reptiles when pressed by hunger. Its freedom from any offensive smell, and the excellence of its flesh, which is much esteemed as an article of food, go far to prove that its habits are chiefly frugivorous. In a domestic state it will eat meat either raw or dressed. Mr Hodgson's specimen, however, was fed mostly on boiled rice, mixed with ghee, and made into large balls. It was never observed to take any water. Whenever it swallowed a mouthful which on second thoughts it considered as somewhat too large, it imme-

[1] *Wanderings in New South Wales*, i. 222.

[2] *Edinburgh Cabinet Library*, British India, iii. 90.

Scansores. diately disgorged it for the sake of a little additional mastication.[1]

Order III.—SCANSORES or CLIMBERS.

This somewhat heterogeneous group, continued by Baron Cuvier as a separate order, forms, in the systems of our own more recent writers, merely an additional tribe in the primary division of the passerine or insessorial order. As the zoological treatises in our present work have been hitherto made conformable to the general principles which regulate the arrangement proposed by the great French anatomist, we shall not here swerve from our previous practice, although we doubt not, that among some recent alterations for the worse, there may also be found not a few for the better. We fear, however, that it may be some time before the Scansores, even of the modern systems, can be regarded as composed of very closely allied groups,—at least so long as people feel averse to see any natural connection between a creeper and a cockatoo. Be this as it may, our present order is composed of species the great majority of which possess two toes before and two behind; that is, one of the three anterior toes commonly so called, is either reversible at pleasure, or is permanently thrown backwards, so as to give great power and tenacity of grasp during their infinitely varied movements over the rugged bark or smoother branches of the forest trees, on which they chiefly dwell. By this peculiar structure many species are enabled not only to ascend with ease a perpendicular trunk, but to suspend themselves from the lower surface of a branch while searching for their favourite food, which consists of fruits or insects, according to the form of the bill, so greatly diversified in the scansorial order. In the parrot tribe the foot is also used in the conveyance of food to the mouth, and generally as a prehensile organ of a very perfect kind.

We are aware that more than one excellent Ornithologist has objected to the title of this order, as incapable of being strictly applied to the whole of the genera of which it is composed. It is no doubt true that many of the species (such as the cuckoo), in which the toes are in pairs, or yoke-footed, cannot climb, while it is equally evident that several other species (such as the creeper, *C. familiaris*, the already alluded to very distant connection of the cockatoo) are excluded from this order by reason of the structure of their feet, in spite of which, however, they contrive to climb unceasingly; and that under these circumstances the denomination cannot be rigorously applied as alike characteristic of what it contains, and as correctly exclusive of what it does not contain. But we believe the same objection may be made to apply at least with equal force to various parts of every other system yet proposed. The ordinal characters, considered in their totality, are seldom so natural, yet extended, as to admit of no exception; and it is extremely questionable whether a title should be immediately changed upon the discovery of every species which may not coincide with its most rigorous interpretation. In truth, this could not in many cases be effected merely on the consideration of a single character, without producing greater inconveniences than those which it is desired to obviate. Among scansorial birds, for example, we have several species with only three toes, and which it would therefore be unreasonable to expect should conform to the ordinal character of having two toes before and two behind. But in spite of that partial deficiency, they are, in every essential particular, "true to their order."

Scansores. The bill in the scansorial tribes varies so greatly in the different genera, from the straight, lengthened, angular mandibles of the woodpeckers, to the deep, curved, compressed organ of the parrots, that we must omit all consideration of it in the ordinal characters, although the study of its form is essential in relation to the minor divisions. The species of this order are, with few exceptions, inhabitants of the forests, and usually build their nests in the hollows of ancient trees. Their powers of flight are not remarkable. The European genera are almost entirely insectivorous; the parrot tribe feed on fruits; the toucans exhibit a tendency to the carnivorous habits of the accipitrine tribes; while other genera sensibly enjoy a mingled or miscellaneous diet.[2]

The genus Galbula, Brisson, has a straight, elongated, sharp-pointed bill, with the upper edge rather sharp; the legs are very short, and the anterior toes much united. (Plate XI., figure 1.) The plumage of these birds usually, known under the name of *Jacamars*, is remarkable for its metallic lustre. The species inhabit South America, where they occur among trees in moist and marshy places. Examples, *G. paradisea* and *viridis*, Lath. They generally sit, according to Mr Swainson, on low naked branches in the forest paths, from whence they dart upon butterflies, spearing them with their long bills; and their haunts, indeed, may be frequently discovered by the ground being strewed with the beautiful wings of their mangled victims, the bodies of which they alone devour.[3] "A bird called jacamar," says Waterton, "is often taken for a king-fisher, but it has no relationship to that tribe; it frequently sits in the trees over the water, and as its beak bears some resemblance to that of the king-fisher, this may probably account for its being taken for one; it feeds entirely upon insects; it sits on a branch in motionless expectation, and as soon as a fly, butterfly, or moth passes by, it darts at it, and returns to the branch it had first left. It seems an indolent, sedentary bird, shunning the society of all others in the forest. It never visits the plantations, but is found at all times of the year in the woods. There are four species of jacamar in Demerara; they are all beautiful; the largest, rich and superb in the extreme. Its plumage is of so fine a changing blue and golden green, that it may be ranked with the choicest of the humming-birds. Nature has denied it a song, but given it a costly garment in lieu of it. The smallest species of jacamar is very common in the dry savannas. The second size, all golden green on the back, must be looked for in the Wallaba forest. The third is found throughout the whole extent of these wilds; and the fourth, which is the largest, frequents the interior, where you begin to perceive stones in the ground."[4] An Indian species (M. Lesson, however, assigns it to Cayenne), of which the bill is shorter, thicker, and somewhat arched, forms the genus Jacamerops of Le Vaillant (see Plate XI., figure 2); and another from South America, with only three toes (*G. tridactyla*, Vieil.), constitutes the genus Jacamar-alcyon (Plate XI., figure 3). These names, however unmusically composed, point out the natural relationship of our present group to the bee-eaters and king-fishers, with which (as *fissirostral* birds) they are combined in some modern systems.

The genus Picus, Linn., contains the well-marked, numerous, and extensively distributed tribe of woodpeckers, which occur in all the great divisions of the earth, with the exception of New Holland. The vast and solitary forests of North and South America are, however, their chief dominion, the greatest number, both there and in the old world, being found within the tropics. The bill is rather long, straight, angular, somewhat compressed or wedge-

[1] *Transactions of the Physical Class of the Asiatic Society of Bengal*, part i. p. 178.
[2] Wilson's *Illustrations of Zoology*, vol. i. art. Scansores.
[3] *Nat. Hist. and Class. of Birds*, ii. 164.
[4] *Wanderings*, p. 137.

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shaped at the extremity, and admirably fitted for splitting the bark or excavating the decayed portions of trees. The tongue is long, and capable of great protrusion, in consequence of its muscular basis, and the length of the horns of the *os hyoides*. It is not only furnished with little spines pointing backwards, but is covered by a glutinous moisture secreted by the salivary glands, which aids in the capture of the smaller insects, the larger, it is said, being usually transfixed by the point itself. The tail-feathers are very stiff and elastic, and greatly aid the motion of the feet in climbing, being pressed upon the bark, so as in some measure to support the body. Woodpeckers are shy and solitary birds. During the breeding season they dwell in pairs, and are only met with in small family flocks throughout the autumn. With the exception of the parrots, they form the most extensive group among scansorial tribes, between one and two hundred species being known to naturalists. We have only four in Britain, viz. the green woodpecker (*P. viridis*), our most common species; the great black woodpecker (*P. martius*), which is a much rarer bird; the great spotted woodpecker (*P. major*); and the lesser spotted kind (*P. minor*). Besides these, several others occur on the continent of Europe.

In whatever clime or country woodpeckers are found, they are characterized by strong affinities of form and colour, and constitute a very natural group, although some slight modifications of the bill have given rise in recent times to the formation of a few subgenera.

Buffon has drawn a melting picture of the miseries of a woodpecker's life. According to the views of the always eloquent, but frequently erroneous and sometimes inconsistent Frenchman, no bird which earns its subsistence by spoil leads a life of such painful and uninterrupted labour. Nature appears to have condemned it to incessant toil,—for while other species freely employ their courage or address, and either glide along on fearless rapid wings, or lurk insidiously in closer ambush, the woodpecker is constrained to drag on a miserable existence in boring through the scaly bark and tough unyielding fibres of the hardest trees. Necessity admits no intermission of its labours,—no interval of sweet repose. Not even the darkness of the night, nor sleep, that "soft restorer," who throws her balmy mantle over such a mass of human misery, brings any solace here,—for the nocturnal hours are spent in the same constrained and painful posture as are those of day. It never shares in the joyous sports of the other inhabitants of the woods, and so far from joining in their glad responses, it rather deepens the natural sadness of the forest glades by its wild and melancholy cries. Now, what is all this but the most fantastic coinage of the brain?—as if the blessed beings which people this gladsome world endured the primal curse, and shared the self-inflicted ruin of our race! as if their joyful hearts were ever pressed by sorrow, or responded in wailing sadness to the woes of man! Spirit of Eblis! not yet has thy malign influence so encroached upon the "Benigner Power." Is there any thing on earth for which we may not cry alas! saving only the omnipotent goodness of God, who careth "for all his creatures,"—and amid the unmeasured wretchedness which springs from human folly, the wan faces of our fellow-men pent up in close-built cities, the drunkard's hollow eyes, his shaking limbs, and tattered garments (and all the horrid ills that vice is heir to), what is more inspiring than to see even a fragment of the face of nature,—some little open plot of garden ground, where in spring the blackbird still may sing his evening hymn, or the autumnal red-breast cheerily announce approaching winter? Is there sorrow there or suffering, save what may spring from some dark spirit in the mind of man, the "immortal rebel?" When Buffon himself, a great interpreter of nature, in spite of all his fitful fancies, yielded up his life to God who gave it, did the lilied fields of France reflect the sun's warm rays less brightly, or her sylvan choristers welcome with sadder note the rosy day-break of the ensuing morn; or when that more wretched hour arrived (which the hoary but irreverent parent was saved the pain to see) when his son's fair locks, dishevelled but not dishonoured, were streaming on the blood-stained floor of that insatiate scaffold, what cared the gladsome birds in field or tree? It would indeed be but a doleful thought, if misery such as man so often meets with among human kind, and which he is therefore prone to picture, were to spread itself from his own sad bosom into the depth of darkly shaded forests, where so many gorgeous feathered inmates dwell, or among ocean rocks amid upheaving waters, or wave-worn caves, or crystal rivers with their golden sands.

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Let those who dwell with pity on the fate of our condemned bird go with us to America, and listen to the high-toned note of *Picus principalis* (the name itself might "threaten and command"), echoing from the giant trunk or moss-grown arm of some colossal tree, or watch his varied movements, while from gnarled stems he drives off impetuously broad flakes of flashing bark, which so accumulate around the base of pine or cypress, as if a human carpenter had there set up his habitation. Or if we cannot go to America, let us read a great observer's history of another species. "No sooner," says Audubon, "has spring called them (the golden-winged woodpeckers) to the pleasant duty of making love, than their voice, which by the way is not at all disagreeable to the ear of man, is heard from the tops of high decayed trees, proclaiming with delight the opening of the welcome season. Their note at this period is merriment itself, as it imitates a prolonged and jovial laugh, heard at a considerable distance. Several males pursue a female, reach her, and to prove the force and truth of their love, bow their heads, spread their tails, and move sideways, backwards and forwards, performing such antics as might induce any one witnessing them, if not of a most morose temper, to join his laugh to theirs. The female flies to another tree, where she is constantly followed by one, two, or even half a dozen of these gay suitors, and where again the same ceremonies are gone through. No fightings occur, no jealousies exist among these beaux, until a marked preference is shown to some individual; when the rejected proceed in search of another female. In this manner all the golden-winged woodpeckers are soon happily mated. Each pair immediately proceed to excavate the trunk of a tree, and finish a hole in it sufficient to contain themselves and their young. They both work with great industry and apparent pleasure. Should the male, for instance, be employed, the female is close to him, and congratulates him on the removal of every chip which his bill sends through the air. While he rests he appears to be speaking to her on the most tender subjects, and when fatigued is at once assisted by her. In this manner, by the alternate exertions of each, the hole is dug and finished. They caress each other on the branches, climb about and around the tree with apparent delight, rattle with their bill against the tops of the dead branches, chase all their cousins the red-heads, defy the purple-grakles to enter their nest, feed plentifully on ants, beetles, and larvæ, cackling at intervals, and ere two weeks have elapsed, the female lays either four or six eggs, the whiteness or transparency of which are doubtless the delight of her heart. If to raise a numerous progeny may contribute to happiness, these woodpeckers may be happy enough, for they have two broods each season. Even in confinement the golden-winged woodpecker never suffers its naturally lively spirit to droop. It feeds well, and by way of amusement will contrive to destroy as much furniture in a day as can well be mended by a different kind of workman in two. Therefore, kind reader, do not any longer believe that woodpeckers, I mean those of

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America, are such stupid, forlorn, dejected, and unprovided-for beings, as they have hitherto been represented."[1]

The other species to which we have above alluded is the beautiful ivory-billed woodpecker (*Picus principalis*, Linn.), of which the broad extent of dark and glossy plumage, with the well-defined snowy markings of the neck and wings, relieved by the rich tracery of the carmine crest, and brilliant yellow eye, in some way so reminded the enthusiastic Audubon of the noble productions of a great Flemish painter, that whenever he saw one of these gorgeous birds flying from tree to tree, he would exclaim, "There goes a Vandyke." The ivory-billed woodpecker confines its rambles to a comparatively small portion of the United States, and is never observed in the middle portions of the Union, where the nature of the wood does not appear to suit its habits. "Descending the Ohio," says Mr Audubon, "we meet with this splendid bird for the first time near the confluence of that beautiful river and the Mississippi; after which, following the windings of the latter, either downwards towards the sea, or upwards in the direction of the Missouri, we frequently observe it. On the Atlantic coast, North Carolina may be taken as the limits of its distribution, although now and then an individual of the species may be accidentally seen in Maryland. To the westward of the Mississippi, it is found in all the dense forests bordering the streams which empty their waters into that majestic river from the declivities of the Rocky Mountains. The lower parts of the Carolinas, Georgia, Alabama, Louisiana, and Mississippi, are however the most favourite resorts of this bird, and in those states it constantly resides, breeds, and passes a life of peaceful enjoyment, finding a profusion of food in all the deep, dark, and gloomy swamps dispersed throughout them. I wish, kind reader, it were in my power to present to your mind's eye the favourite resort of the ivory-billed woodpecker. Would that I could describe the extent of those deep morasses, overshadowed by millions of dark gigantic cypresses, spreading their sturdy moss-covered branches, as if to admonish intruding man to pause and reflect on the many difficulties which he must encounter should he persist in venturing farther into their almost inaccessible recesses, extending for miles before him, where he would be interrupted by huge projecting branches, here and there the massy trunk of a fallen and decaying tree, and thousands of creeping and twining plants of numberless species! Would that I could represent to you the dangerous nature of the ground, its oozing, spongy, and miry disposition, although covered with a beautiful but treacherous carpeting, composed of the richest mosses, flags, and water-lilies, no sooner receiving the pressure of the foot than it yields, and endangers the very life of the adventurer, whilst here and there, as he approaches an opening, that proves merely a lake of black, muddy water, his ear is assailed by the dismal croaking of innumerable frogs, the hissing of serpents, or the bellowing of alligators! Would that I could give you an idea of the sultry pestiferous atmosphere, that nearly suffocates the intruder during the meridian heat of our dogdays, in those gloomy and horrible swamps! But the attempt to picture these scenes would be vain. Nothing short of ocular demonstration can impress any adequate idea of them.

"The flight of this bird is graceful in the extreme, although seldom prolonged to more than a few hundred yards at a time, unless when it has to cross a large river, which it does in deep undulations, opening its wings at first to their full extent, and nearly closing them to renew the propelling impulse. The transit from one tree to another, even should the distance be as much as a hundred yards, is performed by a single sweep, and the bird appears as if merely swinging itself from the top of the one tree to that of the other, forming an elegantly curved line. At this moment all the beauty of the plumage is exhibited, and strikes the beholder with pleasure. It never utters any sound whilst on wing, unless during the love season; but at all other times, no sooner has this bird alighted, than its remarkable voice is heard, at almost every leap which it makes, whilst ascending against the upper parts of the trunk of a tree, or its highest branches. Its notes are clear, loud, and yet rather plaintive. They are heard at a considerable distance, perhaps half a mile, and resemble the false high note of a clarionet. They are usually repeated three times in succession, and may be represented by the monosyllable, *pait, pait, pait.* These are heard so frequently, as to induce me to say that the bird spends few minutes of the day without uttering them; and this circumstance leads to its destruction, which is aimed at, not because (as is supposed by some) this species is a destroyer of trees, but more because it is a beautiful bird, and its rich scalp, attached to the upper mandible, forms an ornament for the war-dress of most of our Indians, or for the short pouch of our squatters and hunters, by all of whom the bird is shot merely for that purpose.

"Travellers of all nations are also fond of possessing the upper part of the head and the bill of the male; and I have frequently remarked, that on a steam-boat's reaching what we call a *wooding-place*, the *strangers* were very apt to pay a quarter of a dollar for two or three heads of this woodpecker. I have seen entire belts of Indian chiefs closely ornamented with the tufts and bills of this species, and have observed that a great value is frequently put upon them. The food of this species consists principally of beetles, larvæ, and large grubs. No sooner, however, are the grapes of our forests ripe, than they are eaten by the ivory-billed woodpecker with great avidity. I have seen this bird hang by its claws to the vines, in the position so often assumed by a tit-mouse, and, reaching downwards, help itself to a bunch of grapes with much apparent pleasure. Persimons are also sought for by them, as soon as the fruit becomes quite mellow, as are hag-berries. The ivory-bill is never seen attacking the corn, or the fruit of the orchards, although it is sometimes observed working upon and chipping off the bark from the belted trees of the newly-cleared plantations. It seldom comes near the ground, but prefers at all times the tops of the tallest trees. Should it, however, discover the half-standing broken shaft of a large dead and rotten tree, it attacks it in such a manner as nearly to demolish it in the course of a few days. I have seen the remains of some of these ancient monarchs of our forests so excavated, and that so singularly, that the tottering fragments of the trunk appeared to be merely supported by the great pile of chips by which its base was surrounded. The strength of this woodpecker is such that I have seen it detach pieces of bark seven or eight inches in length at a single blow of its powerful bill, and by beginning at the top branch of a dead tree, tear off the bark, to an extent of twenty or thirty feet, in the course of a few hours, leaping downwards with its body in an upward position, tossing its head to the right and left, or leaning it against the bark to ascertain the precise spot where the grubs were concealed, and immediately after renewing its blows with fresh vigour, all the while sounding its loud notes, as if highly delighted.

"When wounded and brought to the ground, the ivory-bill immediately makes for the nearest tree, and ascends it with great rapidity and perseverance, until it reaches the top branches, when it squats and hides, generally with

[1] *Ornithological Biography*, vol. i. p. 191.

Scansores. great effect. Whilst ascending, it moves spirally round the tree, utters its loud *pait, pait, pait,* at almost every hop, but becomes silent the moment it reaches a place where it conceives itself secure. They sometimes cling to the bark with their claws so firmly, as to remain cramped to the spot for several hours after death. When taken by the hand, which is rather a hazardous undertaking, they strike with great violence, and inflict very severe wounds with their bill as well as claws, which are extremely sharp and strong. On such occasions, this bird utters a mournful and very piteous cry."[1]

A few species in which the bill is obviously arched form the genus COLAPTES of Mr Swainson. They seem, moreover, distinguished by the broad, bright-coloured shafts of the quill-feathers. Such is the gold-winged woodpecker (*P. auratus*) already alluded to. These birds *perch* more frequently than the genuine woodpeckers, that is, grasp or encircle the smaller branches, and they also often feed upon the ground. A Brazilian species is even named *P. campestris,* from its habit of searching about in fields and plains for insects in the dung of cattle, or on ant-hills, where it finds an ample supply of favourite food. This form occurs also in Africa. Certain three-toed species were formed into the genus PICOIDES by Lacepede. (Plate CCCXCV. fig. 3.)

The genus YUNX of Linn., containing the wrynecks, remarkable for their beautifully brindled plumage, is of very limited extent. The sole European species (*Yunx torquilla*) is in Britain a rare but regular summer bird of passage, breeding in hollow trees, laying numerous eggs, and feeding on insects. The genus PICUMNUS of Temm. is nearly allied, but is distinguished by its extremely short tail. Example, *P. abnormis,* Temm. *Pl. Col.* 371, fig. 3, which comes from Java. *Picus minutus,* which some authors place here, is by others regarded as a *Yunx.*

In the genus CUCULUS of Linn. were originally placed a number of different insectivorous birds, commonly called cuckoos, which agreed in the general form of the feet, the lengthened tail, the bill of medium size, rather deeply cleft, somewhat compressed, and slightly curved. But they have since been formed into numerous minor groups, the most marked and conspicuous of which we shall here briefly notice.

The true cuckoos, genus CUCULUS, Cuv., have the bill of moderate strength, the tarsi short, and the tail of ten feathers. As an example, we name our common British species, *C. canorus,* so remarkable for its singular and somewhat anomalous habit of depositing its eggs in the nests of other birds, a fact now so well known, and so frequently recorded, that we need not here dilate upon the subject, however curious in itself. The nest of the hedge-sparrow (*Accentor modularis*) is that most usually chosen in the south of England,—that of the yellow-hammer (*Emb. citrinella*), the wagtail (*Mot. alba*), and the meadow titlark (*A. pratensis*), being, however, likewise devoted to the purpose. "In Northumberland," says Mr Selby, "constant experience tells me, that the nest of the last-mentioned bird is the one almost always chosen. Taking advantage of the absence of its dupe during the time of laying (which generally occupies four or five days), the cuckoo deposits its egg among the rest, abandoning it from that moment to the care of the foster-parent. As the same period of incubation is common to both birds, the eggs are hatched nearly together, which no sooner takes place than the young cuckoo proceeds instinctively to eject its young companions and any remaining eggs from the nest. To effect this object, it contrives to work itself under its burden (the back at this early age being provided with a peculiar depression between the shoulders), and shuffling backwards to the edge of the nest, by a jerk rids itself of the incumbrance; and this operation is repeated, till the whole being thrown over, it remains sole possessor. This particular tendency remains for about twelve days, after which the hollow space between the shoulders is filled up; and when prevented from accomplishing its purpose till the expiration of that time, as if conscious of inability, it suffers its companions to remain unmolested."[2] Scansores.

Various supposed reasons have been assigned for this anomalous, and we might almost say unnatural, instinct. Some have attributed it to the displacement of certain viscera (the gizzard is said to be situate farther back than in most other birds), which unfits them for the purposes of incubation, while others imagine that the early period at which cuckoos migrate from this country (they are generally off by the beginning of July) makes it necessary that they should leave their offspring to the care of foster-parents.[3] But anatomical investigation has not proved any thing sufficiently peculiar in their structure to warrant the first conclusion; and as to the second, it seems to us not so much a deduction from a regulating and causative fact in their history, as the statement of an additional circumstance which renders that history still more singular, and which naturally leads to the question, not easily answered, of why do they migrate so early?[4] In short, we know nothing at all about the matter, further than that the cuckoo of Europe, like the cow-bunting of America, always lays eggs, but never hatches them. The same custom is alleged, we think upon a narrow and ill-considered generalization, to characterize the other kinds of cuckoo. It may be a practice common to several species, but the rare black and white spotted cuckoo (*Cuculus Pisanus,* Gm., an odd name for an African bird, which happened once upon a time to visit Tuscany) is stated by the authors of the *Storia degli Uccelli* to have *built a nest* in the woods of Pisa, and *reared four young ones.* This species is extremely rare in Europe. It is known, however, in the Genoese territory,[5] and the young have been occa-

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[1] *Ornithological Biography,* i. 341. [2] *British Ornithology,* vol. i. p. 398. [3] *British Ornithology,* vol. i. p. 399.

[4] Besides, in Italy and other southern parts of Europe, this migration does not take place till September, and yet the habits of the bird are precisely the same. "Quelli uccellini," says Savi, "nel covo de' quali il cuculo ha lasciato l'uovo, non vi fanno attenzione; come uno de' loro seguitano a covarlo, e quando è nato imboccano e custodiscono il piccolo cuculo, con lo stesso amore, e con la cura medesima de' figli propri. Ma ben presto egli paga d'ingratitudine le premure dell'amorosa sua balia: crescendo molto più de' compagni, dopo poco tempo il nido è per lui troppo stretto: allora ricorre a un barbaro espediente per procurarsi un alloggio più comodo:" &c...." Ripete quest operazione successivamente, in ragione che cresce, e che gli altri compagni lo incomodano, di modo che alla fine rimane solo nel nido usurpato. Così quei miseri uccelli che construirono il nido e che han fatto da balia al cuculo, sono da lui privati ad uno ad uno di tutti i figli." Regarding the movements of the parent bird in Italy, he observes, "E uccello migratorio: arriva nell' Aprile, e parti in Settembre. Appena arriva comincia a cantare, e quantunque il suo verso non abbia alcuna varietà, non ostante la voce essendo dolce e rotonda, si sente con piacere. Grandissimo è il numero che ne rimane in Toscana: non vi è bosco in monte o in piano, che in primavera ed in estate, non risuoni dal *cu cu, cu cu,* di questo uccello. Nel Settembre comincia a muoversi per emigare: allora in alcuni anni se ne vede passare una quantità grandissima per la pianura Pisana. Nel Settembre del 1823, gli alberi dello stradone che da Pisa va al Parco Reale di S. Rossore, attraversando vastissime praterie, ne furono pieni per una diecina di giorni. Volavano i cuculi da una pianta all' altra, andavano a posarsi un poco sul prato, ritornavano sugli alberi, ma di lì non si allontanavano, benchè continuamente fossero molestati dai non pochi cacciatori che vi erano accorsi. Questi uccelli volano con grande agilità, e spesso, particularmente andando a posarsi, senza muovere le ali, come sogliono fare i Falchi." (*Ornitologia Toscana,* t. i. p. 152.)

[5] Calvi, *Catalogo d'Ornitologia di Genova,* p. 55.

Scansores. sionally killed in the south of France.[1] Many beautiful cuckoos are found in foreign countries.

Those of North America belong to the genus Coccyzus of Vieillot, and are distinguished by a greater length of tarsus. (Plate XI., figure 4.) They seem to delight more in deep woody solitudes than the true cuckoos, the latter being often found on hilly pastures and open heathy ground, if fringed with wood. A stranger who visits the United States for the purpose of examining their natural productions, and passes through the woods in May or June, will sometimes hear, as he traverses the borders of deep, retired, high-timbered hollows, an uncouth guttural sound. He will frequently hear this without being able to discover the source from which it comes, as the yellow-billed cuckoo (*Coccyzus Americanus*) is both shy and solitary, and always seeks the thickest foliage for concealment. This bird is of a grayish brown, with bronzed reflections, beneath white, the inner vanes of the primaries reddish cinnamon colour, the lower mandible white, and the length from bill to tail about twelve inches. Considerable discussion has taken place among philologists regarding the native languages of North and South America,—remarkable, we are led to understand, for their great number and striking dissimilarity. We know not what may be the intention of the yellow-billed cuckoo in speaking as he does, or whether he is distinctly comprehended by his neighbours; but the following is Mr Nuttall's account of the elements of his conversation: "The male frequently betrays his snug retreat by his monotonous and guttural *kow kow kow kow*, or *koo koo koo koo*, and *ko kuk, ko kuk, koo koo koo kuk, koo ko koo, koo ko koo*, uttered rather plaintively, like the call of a dove. At other times the *kow kow kow kow*, and *'tk 'tk 'tk 'tk 'tak*, or *'kh 'kh 'kh 'kh 'kak, kow kow kow kow*, beginning slow, rises, and becomes so quick as almost to resemble the grating of a watchman's rattle, or else, commencing with this call, terminates in the distant cry of *kow kow kow*." From this peculiar iteration (Shakspeare would have called it "damnable," a word we sometimes hear in pulpits, but ourselves but seldom use), the species in question has received the name of *kow*-bird, and we do not wonder at it. It may be satisfactory to know, that the St Domingo cuckoo (*C. Dominicus*, Nut.) although it sometimes cries both *kow kow kow kow* and *'kh 'kh 'kh 'kh 'kh 'kak*, yet often utters, in a raucous guttural voice, especially preceding rain, a word which sounds like *orrattottoo* or *worrattottoo*, exactly which has not been yet determined.

In the genus Centropus of Illiger the bill is compressed and carinated, and the nail of one of the hind toes is long, straight, and pointed, like a lark's. The tail is greatly elongated. The species are native to India and Africa, where they build in hollow trees, and feed on locusts and other insects. Such are *Cuculus Ægyptius, Senegalensis, Bengalensis*, &c. The genus Leptosomus of Vieillot is constituted by the great Madagascar cuckoo (*C. cafer*, Lath.—*Lep. viridis*, Vieil.), the female of which, as described by Buffon, is according to M. Lesson a distinct species—*Lept. crombus*. These birds are said to be frugivorous. (Plate XI., figure 5.)

In the genus Indicator, Vail., the bill is short, high, almost conical. (Plate XI., figure 6.) The tail consists of twelve feathers, and is somewhat graduated, and at the same time a little forked. The skin is described to be so hard and tough as to resist the assaults of most hymenopterous insects; but bees, which they incessantly torment, are said to sting them in the eyes. The species, few in number, are known by the name of honey-guides, and inhabit Africa. The one mentioned by Sparrman is said to attract the notice of the Dutch and Hottentots by a shrill cry of *cher, cher*; and when it perceives itself observed, it flutters onwards to the hive of a wild bee, in hopes of partaking of the plundered honey. "I have had frequent opportunities," he observes, "of seeing this bird, and have been witness to the destruction of several republics of bees, by means of its treachery. I had, however, but two opportunities of shooting it, which I did, to the great indignation of my Hottentots." It may be here noticed, we hope without offence, that naturalists themselves seem not seldom to belong to that *irritabile genus*, of which poets are usually supposed to form the greater portion. Though Dr Sparrman asserts that he was a frequent eye-witness of the curious instinctive habits of the honey-guide, yet Vaillant doubts if that traveller ever saw the bird at all. He says that the account is merely a repetition of a fable believed and repeated by credulous people at the Cape, and that it is erroneous to suppose that the bird seeks to draw man after it for the purpose of sharing the plundered sweets, the fact being, that it calls not the man, but that the latter knows, by attending to the cry of the honey-guide while searching for its natural food, that he will be sure ere long to find the stores of the industrious insect. According to Bruce, the *moroc*, for so this singular species is sometimes named, occurs in Abyssinia; and he too throws discredit on Sparrman's statements,—his own being but ill received by not a few. However, Sir John Barrow, a careful and accurate inquirer, though not a professed naturalist, confirms it by stating that people in the interior of the South of Africa are too well acquainted with the moroc to have any doubts, either as to the bird itself, or its singular instinctive habits. Scansores.

The *Barbacous* of Vaillant (genus Monasa, Vieil.) are South American birds, with rather conical elongated bills, slightly arched towards the tip, and furnished at the base with setaceous feathers. (Plate XI., figure 7.) Such are *Cuc. tranquillus* and *tenebrosus* of the older systems, and the *Bucco albifrons* of Spix. We believe they are insectivorous. The *Malcohas* of Vaillant, again (genus Phœnicophæus, Vieil.), are Asiatic species, of which the most anciently known is native to Ceylon. (Plate XII., fig. 1.) We here place the *Cuculus curvirostris* of Shaw, Latham's red-headed cuckoo, *C. pyrrhocephalus* of Forster, &c. and certain recent species described by Dr Horsfield and Sir Thomas Raffles. The preceding groups were all regarded as cuckoos by the older authors.[2]

The genus Scythrops of Latham, however, has a much stronger bill than any of these, marked by two slight longitudinal furrows. There is a naked space around the eye, and the nostrils are rounded. Only a single species is yet known, *Sc. Novæ Hollandiæ*, Lath., sometimes called the channel bill, a most peculiar looking bird, of the size of a crow, gray above, beneath dingy white. (Plate XII., fig. 2.) In its bill it almost assimilates to the toucans, but its tongue is simple. Though it is mentioned both by White and Phillips, we know as yet but little of its habits. It occurs in New Holland, where it is sometimes seen in small flocks, but more usually in pairs, frequenting trees, and uttering during flight a loud and screaming cry, not unlike the crowing of a cock. Its food is said to consist both of fruits and insects. It also occurs in the Celebes, where its voice presages rain.

The genus Bucco of Linn., is characterized by a thickish conical beak, bulged laterally from the base, and furnished with five fasciculi of barbs directed forwards. The wings

[1] Roux, *Ornithologie Provençale*, p. 105.

[2] For the various modifications of form exhibited by the Cuculidæ, and the numerous minor groups which have thence resulted, see M. Lesson's *Traité d'Ornithologie*, and a paper by Mr Swainson in the *Magazine of Zoology and Botany*.

Scansores. are short, and the flight heavy. The species feed on fruits and insects, and occasionally attack small birds. They build their nests in hollow trees. Cuvier divides them into three minor groups. The *Barbicans* of Buffon (POGONIAS, Illiger) have one or two strong teeth on each side of the upper bill, of which the ridge is arched and blunt. The barbs are very strong. (Plate XII., figure 3.) The species occur in Africa and India, and are more frugivorous than their congeners. Example, *P. suleirostris*, Leach, *Zool. Misc.* xi. 76. The Barbus (genus BUCCO, as restricted) have the bill simply conic, slightly compressed, the culmen blunt, and a little raised about the centre. The species live in pairs during the breeding season, and in small flocks at other times. They occur in both continents, and are adorned with lively colours,—*Bucco grandis, viridis, flavifrons*, &c. Lastly, the *Tamatias*, genus TAMATIA, Cuv., have the bill more elongated and compressed, with the extremity of the upper mandible curved downwards. Their thick heads, large bills, and short tails. give them a stupid aspect. They inhabit South America, feed on insects, and are of solitary habits. Example, *T. melanoleucos, melanotis*, &c. They are known by the English name of *puff-birds;* and Mr Swainson describes them as sitting for hours together on a dead or withered branch, from which they dart from time to time on such unwary insects as approach within their reach. He adds, that the hermit-birds (genus *Monasa*), already mentioned, do the same, and frequently rise up perpendicularly into the air, making a swoop, and returning again to their former station. Similar manners belong to the jacamars, though their flight is weaker.

In the genus TROGON the bill is also bearded, but short, and broader than high, the upper edge rounded. Their little feet are often feathered almost to the toes, and their soft, full, lax plumage, and lengthened tails, bestow upon the species a peculiar aspect. (Plate XII., figure 4.) These birds abound in South America, where they conceal themselves in the central solitudes of umbrageous forests, and, except during the breeding season, dwell insulated and alone. They will sit motionless for half a summer's day, often upon a withered branch, and if not concealed by some accidental intervening mass of foliage, they fall an easy prey to the keen-eyed hunter, who eagerly searches for birds not less remarkable for the delicacy of their flesh than the beauty of their plumage. During the morning and evening hours, Mr Swainson informs us, they become more active; venturing at these times into the open parts of the forest, and, taking a shady station, dart upon winged insects, particularly beetles. At other times they feed upon fruits, especially the rich purple berries of the different melastomæ, "at which," says Mr Swainson, "they invariably dart, precisely as if they were insects capable of getting away." It has been remarked by the woodland hunters, that the skins of these birds are of such delicate texture as to be with difficulty preserved in a natural or complete condition. It is probably for this reason that in museums they exhibit a heavy, shapeless aspect, redeemed, it is true, by the gorgeous colours or metallic splendour of their plumage. The most magnificent of the genus is the quezal or golden trogon (*T. pavoninus*, Temm.), a rare and remarkable species, of which neither delineation nor description can convey an adequate idea. The greater proportion of the plumage is apparently composed of burnished gold. The head ornamented by a brilliant crest of decomposed barbs, the wing-coverts falling in flakes of golden green over the deep purplish-black of the primary and secondary quill-feathers, the rich carmine of the lower parts bestowing a warmth and depth of effect which no Venetian painter ever equalled, and the long waving and highly metallic feathers of the tail-coverts, extending about three times the length of the whole body, present a combination of beauty almost unexampled in the feathered tribes. The first specimens seen in this country were brought, we believe, by Mr Schenley from Vera Paez, in central America. They are celebrated in the Mexican mythology, and are much sought after as head-gear by the Peruvian damsels. Trogons, of other kinds, occur also in the Indian islands, and the warmer continental regions of the old world.[1] Scansores.

The genus CROTOPHAGA, Linn., is recognised by its thick, compressed, arched bill, without dentation, elevated, or surmounted by a vertical cutting crest. (Plate XII., fig. 5.) The species called *anis* or keel-birds inhabit South America and the West Indies. They are of a familiar and gentle disposition in confinement, easily tamed, and may be taught to speak. Their plumage is black, with metallic reflections. They build in bushes (some say upon the ground), and several pairs will lay and hatch together in the same nest, which is made of size proportioned to the partnership. They feed on insects, keep much upon the ground, where they also attack maize and rice. M. Lesson says that *C. major* dwells more habitually on large trees, while *C. minor* prefers the savannahs and marshy meadows. Mr Swainson never saw the common ani perch on any thing higher than a bush.

The genus RAMPHASTOS, Linn., is distinguished by its enormous bill, which in some instances is almost equal in size to the body. It is, however, extremely light, and cellular within, arched towards the extremity, and irregularly toothed along the margins.[2] The tongue is long, narrow, and barbed on each side, like a feather. These birds, commonly called toucans, inhabit South America, where they live habitually in woods, and prey on fruits, eggs, and new-hatched birds. The species are pretty numerous, and almost all distinguished by brilliant colouring, which however is somewhat too strongly contrasted, and consequently deficient in that fine gradation or harmonious blending which beautifies less gorgeous tribes. We have never chanced to see them in the living state, but in museums they present a somewhat awkward aspect, from their disproportioned bills, short feet, and lengthened tails. Their sense of smell is said to be extremely acute,—a faculty by some attributed to an extended ramification of nerves within the nasal portion of the bill. The genus is now divided into two: 1*st*, The toucans proper (genus RAMPHASTOS (Plate XII., figure 6), which have the largest bills, with the ground colour of the plumage usually black, the throat, breast, and rump being more gaily ornamented with white, yellow, and red. 2*dly*, The aracaris (genus PTEROGLOSSUS, Illiger, Plate XII., figure 7), in which the bill is smaller than the head, and the ground colour of the plumage generally green, with red or yellow on the throat and breast. A live specimen of *Ramphastos tucanus*, of which the manners have been described by Mr Vigors, was extremely fond of fruit, both fresh and dried. These it generally held for a short time in the extremity of the bill, touching them with apparent delight with its slender feathered tongue, and then tossing them into its throat by a sudden upward jerk. Its tendency to prey on animals was, however, strongly evinced by the excitement produced by the sight of a living bird; and the carnivorous propensities of another individual are curiously related by Mr Broderip. A goldfinch (though, we repeat, we approve not of the fact), introduced into the toucan's cage, was seized and compressed so suddenly, that the poor little songster had only time to utter a short squeak before it was dead, with its bowels protruding. The toucan then hopped with it to

[1] Mr Gould published a *Monograph of the Trogonidæ*, with sumptuous coloured plates.

[2] On dissection, Professor Traill found it occupied by numerous blood-vessels and expansions of the olfactory nerve.

Scansores. another perch, and began to strip off its feathers. When it was nearly naked, it broke the bones of the wings and legs, taking them in its bill, and giving them a strong lateral wrench. Having reduced the little victim to a shapeless mass, it first swallowed the viscera, and then the remaining parts, piece after piece, not even rejecting the legs and bill. Mr Broderip adds, that he has sometimes observed it return its food from its crop, and swallow it again, after a second mastication.

The genus PSITTACUS, Linn., comprehending the almost innumerable tribe of parrots, lories, parrakeets, maccaws, and cockatoos, has the bill thick, hard, solid, rather short, rounded on all its outlines, deep, curved, and generally sharp-pointed. The tongue is almost always thick, round, and fleshy, and the lower larynx furnished on each side with three peculiar muscles, which probably contribute to the great facility with which these birds acquire the articulate intonation of the human voice. Their strong and powerful jaws are brought into action by muscles more numerous than usual. Their natural food consists of fruits and seeds. They climb trees with the greatest facility, and suspend themselves indifferently from feet or bill. Their voices are harsh and discordant, their forms often elegant, their plumage usually of great richness. They form indeed a magnificent family, abundant in almost every region of the torrid zone, and in the new world extending from the shores of the Ohio to the Straits of Magellan,—thus presenting a vast and varied assemblage of species from every country of the world, excepting the comparatively cold and cloudy clime of Europe. The gorgeous maccaws are characteristic of South America, the cockatoos of New Holland and the Asiatic islands, the lories of the East Indies and the Moluccas; whilst several groups of parrots, parrakeets, &c. are widely distributed over various regions of the earth. Above two hundred different kinds are known to naturalists.

It was the opinion of Buffon that none of the parrot tribe extended either northwards or southwards beyond the twenty-fifth degree, on either side of the equator. Having apparently resolved, *a priori*, on these lines of circumvallation, he despised, as Pennant observed, the authority of the Dutch navigator Spilbergen, who was eye-witness to the woods of Terra del Fuego, the very southern boundary of the Straits of Magellan, in south latitude 44°, being full of them. He might also have cited the evidence of Captain Hood, who saw a parrot at Port Famine; and of Commodore Byron, who notwithstanding the coldness of the climate observed parrots innumerable in the woods of that same harbour. They were found by Captain Cook in New Zealand, by Captain Furneaux at Van Diemen's Land, and by the learned Forster in the raw wet climate of Dusky Bay. The emerald parrot, *Psit. smaragdinus*, Gmel., was discovered in great numbers by Captain King, among thick underwood, in the Straits of Magellan, south latitude 53½°; and others are well known to occur in Macquarrie Island, which lies in latitude 54¼° south. A species inhabits North America, extending even beyond the Illinois River to the neighbourhood of Lake Michigan, in the forty-second degree of north latitude. It was seen by Alexander Wilson in the month of February, flying in flocks along the banks of the Ohio, during a storm of snow, and yet in full rejoicing cry. These, and many similar facts, are now well known to naturalists.

The modern subdivisions of this great natural family are too numerous and minute to be here recorded.[1] We must therefore satisfy ourselves with a brief indication of the principal groups. We presume nobody at this time of day, under the pretence of *popular* reading, desires to be edified by anecdotes of parrots, so we shall devote the little space we can afford for miscellaneous matters, to a few notices of some of the species which have bred in Europe. Of these we may here mention, as the principal, the great blue and buff maccaw (*P. ararauna*); the gray parrot (*P. erythacus*); the sinciale, ring-necked, and pavouan parrakeets (*P. sinciale, torquatus, Guianensis*); and the black-capped or Philippine lory (*P. tricolor*). The general belief is that the parrot tribe will not breed in Europe; but knowing several instances to the contrary, we wish to impress upon the public the probability that many more would occur were the experiment tried with frequency and judgment. Scansores.

The gorgeous maccaws form the genus MACROCERCUS of Vieillot. The face is either naked, or merely striped with feathery lines. The tail is very long, wedge-shaped, and sharp-pointed. (Plate XIII., figure 1.) These birds, the largest and most magnificent of the parrot tribe, inhabit South America. The great scarlet maccaw (*Psittacus aracanga*, Lath.), when in perfect plumage, sometimes measures above three feet in length, the tail of course included. The prevailing plumage is scarlet, as its name implies, the wings blue, the wing-coverts varied with yellow, the cheeks white and wrinkled. It is certainly a sumptuous creature, but after all rather too like a richly liveried footman,—an association somewhat strengthened by its being so often seen as an inhabitant of lordly mansions, and surrounded by other menial bipeds, almost as gorgeous as itself. Our feelings would no doubt have been different had we ever witnessed their natural evolutions. "It is a grand sight in Ornithology," says Waterton, "to see thousands of aras flying over your head, low enough to let you have a full view of their flaming mantle." How delightful would it have been, on some bright and dewy morning, to have accompanied Lord Anson to view a magnificent rapid in the island of Quibo. A fine river of transparent water there precipitates itself along a rocky channel, forming numerous falls, and the great disrupted rocks which form its boundary on either side are crowned with lofty forest trees. "While the commodore and those who were with him attentively viewing the place, were remarking the different blendings of the waters, the rocks, and the woods, there came in sight as it were still more to heighten and animate the prospect, a prodigious flight of maccaws, which hovering over this spot, and often whirling and playing on the wing about it, afforded a most brilliant appearance by the glittering of the sun upon their varied plumage; so that some of the spectators cannot refrain from a kind of transport when they recount the complicated beauties which occurred at this extraordinary water-fall." The blue and yellow species (*P. ararauna*, Linn.) is little inferior to the preceding, either in size or sumptuousness. It is less common, and seems to have been first described by Aldrovandus, from a specimen which he saw in the palace of the Duke of Mantua. It is said to be also less easily reclaimed as a domestic bird,—yet we have not seldom enjoyed the society of a very fine example which made its way familiarly (such is its custom in the afternoon) amid the varied horticultural produce which graced the *dessert* of Dr Neill. Many other splendid species are described and figured in the works of naturalists.

In the genus ARATINGA of Spix, the bill is slender, dentated; the orbits of the eyes naked, the cheeks rarely so; the tail lengthened, wedge-shaped, the intermediate feathers prolonged. The species are peculiar to the new world. Such are *Ar. Carolinæ-Augustæ, chrysocephalus*, &c. To these the genus PSITTACARA of Vigors seems allied, the bill, however, being shorter and stouter, and

[1] Two of the most complete and scientific treatises that can be found on the parrot tribe are,—*Conspectus Psittacorum*, ab H. Kuhl, Ph. Dr. &c., in *Nova Acta Acad. Nat. Cur.* tom. x. p. 1; and Wagler's *Monographia Psittacorum*.

Scarsores. the upper mandible compressed at the tip. The head is feathered, but the orbits are naked. The species, such as *P. squamosus*, &c. are likewise natives of South America.

The genus PALÆORNIS of Vigors has the bill rather thick, the culmen of the upper mandible rounded, the lower broad, short, emarginate. The middle feathers of the tail are greatly lengthened. The most anciently known of the parrot race belong to this genus, such as the Alexandrine parrakeet, and other long-tailed species, distinguished by their elegance of form, their ruby-coloured bills, their semicircled necks, and the rich *verdure* of their plumage. The one just named is native to India and Ceylon, and derives its designation from the fact, real or supposed, of its having been first transported from Asiatic countries by Alexander the Great. Its most distinguishing characters consist in the broad black patch which occupies the fore-part of the throat, and extends laterally in two narrow processes on each side of the neck; a black line stretches from the base of the beak to the eyes, and there is a deep purplish-red patch at the base of the wings. Its bill is larger than that of the rose-coloured parrakeet (*P. torquatus*), which, however, it greatly resembles in its general aspect. The last-named species is widely spread over India, and as far eastward as Manilla. It appears, indeed, to be identical with another species extremely abundant on the African coasts, and well known in France under the title of *perruche de Senegal*. In so far as any conclusion can be drawn from the vague and brief descriptions handed down by ancient writers, it would appear that this species was, as it still continues to be, more frequent in the days of antiquity than any of its congeners. No allusion is made by these authors to those specific marks by which the Alexandrine parrakeet is so clearly distinguished, and the general description applies very closely to the rose-necked kind. That the latter was extensively known, and held in high esteem on account of the brilliancy of its plumage, the docility of its manners, and its successful imitative powers, is proved by innumerable passages in the classical writers of antiquity, more especially from the earliest times of the Roman empire, to a very late period of its annals.[1] The Alexandrine parrot is generally supposed to have been brought to Europe from the island of Ceylon, the ancient Taprobane. In the reign of Nero, the Romans introduced other species from different quarters of Africa.[2] They were highly prized by that luxurious people, who lodged them in superb cages of silver, ivory, and tortoise-shell; and the price of a parrot in those days frequently exceeded that of a slave.[3] Nor did Ovid think it beneath him to write a lengthened elegy on the death of Corinna's favourite,—a bird which, in the love it bore its mistress, seems to have emulated that of the dying Greek for his country:—

Clamavit moriens lingua, Corinna, Vale.[4]

In the same group is generally included that beautiful and richly varied species from the Molucca Islands, called the blue-bellied parrakeet, *Ps. cyanogaster*, Shaw. Its tongue, in common with that of several New Holland parrakeets, is finely ciliated at the tip on either side. Hence Scansores. the formation in their favour of Mr Vigors's genus TRICHOGLOSSUS. Vailliant, during his residence at the Cape, had an opportunity of studying the manners of a pair of the species just named, which had been imported from Amboyna. They bred during their confinement in the menagerie of M. Van Bletemberg, then governor of the Cape. The female deplumed her beautiful breast, and after having collected the feathers into a heap, deposited two round white eggs, on which she sat most assiduously, the male feeding her at intervals, by disinterestedly disgorging what he had swallowed, and presenting the same to his spouse. The young were produced at the end of nineteen days, and in the space of a few more became covered with a gray cinereous down, which was by degrees succeeded by green feathers on the body, and by blue ones on the head. At the end of three weeks they left the nest, and perched upon the neighbouring sticks, where the male and female fed them in concert, as above described, after the manner of pigeons. The parent birds continued to tend them in this manner for six months, and often afforded a very interesting scene,—the young being frequently seated beyond the female, and the male not being able to *reach* them, first presented the food to his mate, who immediately delivered it to her young. These, though of different sexes, were perfectly alike till the first moulting, at which time red feathers bordered with green began to appear upon the breast, and the male became distinguished by the blue patch upon the abdomen.[5]

In the genus PLATYCERCUS, Vigors, the tail is broad, depressed, and somewhat rounded. The species inhabit New Holland, and the islands of the South Pacific and Indian Oceans. Examples *Pl. Pennantii*, *Tabuensis*, &c.

Among the *perruches ordinaires* of Cuvier (a portion of the genus CONURUS, Kuhl), distinguished by a regularly graduated tail, without any disproportionate prolongation of the central feathers, we have the Carolina parrot of Wilson (*Ps. Carolinensis*, Linn.), a green plumaged bird, with yellow head and neck, the forehead and cheeks orange. Of more than two hundred species now known to belong to the parrot tribe, this is the only one which inhabits the United States, where it is chiefly restricted to the warmer portions,—venturing but rarely beyond Virginia. West of the Alleghanies, however, circumstances induce it to visit much higher latitudes,—so that, following the great valley of the Mississippi, it is seen to frequent the banks of the Illinois, and occasionally to approach the southern shores of Lake Michigan. Straggling parties have even been sometimes observed in the valley of the Juniata, in Pennsylvania; and a flock, to the great surprise of the Dutch inhabitants of Albany, are said to have appeared in that vicinity. This species constantly inhabits and breeds in the southern states, and is so far hardy as to make its appearance, commonly in the depth of winter, along the woody banks of the Ohio, the interior of Alabama, and the banks of the Mississippi and Missouri around St Louis and other places, when nearly all other southern birds have migrated

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[1] Ancient writers are unanimous in their statements that parrots came to us first of all from India. Aristotle calls the Psittacus "τὸ Ἰνδικὸν ὄρνεον;" and Arrian also makes it a native of the East (*Hist. Ind.* cap. xv.). The parrots of Africa became first known to the Romans in the time of Nero. (Plin. *Nat. Hist.* lib. vi. c. 29.) For the classical history of these birds, see Mr Vigors's "Sketches in Ornithology,"—*Zoological Journal*, vol. ii. p. 37.

[2] See *Zoological Gardens*, vol. ii. p. 96.

[3] The splendour of a parrot's cage is thus described by Statius:—

At tibi quanta domus, rutila testudine fulgens,
Connexusque ebori virgarum argenteus ordo,
Argutumque tuo stridentia limina cornu,
Et querulæ jam sponte fores: vacat ille beatus
Carcer.—*Sylv.* lib. ii.

[4] *Edinburgh Cabinet Library*, Africa, p. 480.

[5] Shaw's *General Zoology*, vol. viii. p. 414.

Scansores. before the storms of that inclement season.[1] We may judge of the abundance of this species, even up to a recent period, from the statement of Vaillant, who assures us that he saw a package containing above 6000 skins, which had been sent to a *plumassier* at Paris, for the formation of ornamental dresses.[2] Mr Audubon, however, discovered that their numbers were rapidly diminishing, and that in some districts where, not many years ago, they were plentiful, scarcely one was to be seen. "I should think," he adds (speaking of his own time), "that along the Mississippi there is not now half the number that existed fifteen years ago." To illustrate the habits of these birds, we give the following account from the work of an English gentleman who settled in America. "The Carolina parrakeets in all their movements, which are uniformly gregarious show a peculiar predilection for the alluvial, rich, and dark forests bordering the principal rivers and larger streams, in which the towering cypress[3] and gigantic sycamore[4] spread their vast summits, or stretch their innumerable arms, over a wide waste of moving or stagnant waters. From these, the beech, and the hack-berry,[5] they derive an important supply of food. The flocks, moving in the manner of wild pigeons, dart in swift and airy phalanx through the green boughs of the forest; screaming in a general concert, they wheel in wide and descending circles round the tall button-wood, and all alight in the same instant, their green lustre, like the fairy mantle, rendering them nearly invisible beneath the shady branches, where they sit, perhaps arranging their plumage, and, shuffling side by side, seem to caress and scratch each other's heads with all the fondness and unvarying friendship of affectionate doves. If the gun thin their ranks, they hover over the screaming, wounded, or dying, and returning and flying around the place where they miss their companions, in their sympathy seem to lose all idea of impending danger. More fortunate in their excursions, they next proceed to gratify the calls of hunger, and descend to the banks of the river or the neighbouring fields in quest of the inviting kernels of the cockle burr,[6] and probably of the bitter weed,[7] which they extract from their husks with great dexterity. In the depth of winter, when other resources begin to fail, they, in common with the yellow-bird and some other finches, assemble among the tall sycamores,[8] and, hanging from the extreme twigs, in the most airy and graceful postures, scatter around them a cloud of down from the pendant balls, in quest of the seeds which now afford them an ample repast. With that peculiar caprice, or perhaps appetite, which characterizes them, they are also observed to frequent the saline springs or *licks*, to gratify their uncommon taste for salt. Out of mere wantonness, they often frequent the orchards, and appear delighted with the fruitless frolic of plucking apples from the trees, and strewing them on the ground untasted. So common is this practice among them in Arkansas territory, that no apples are ever suffered to ripen. They are also fond of some sorts of berries, and particularly of mulberries, which they eat piecemeal in their usual manner, as they hold them by the foot. According to Audubon, they likewise attack the outstanding stacks of grain in flocks, committing great waste; and on these occasions, as well as the former, they are so bold or incautious as readily to become the prey of the sportsman in great numbers. Peculiarity of food appears wholly to influence the visits and residence of this bird, and in plain, champaign, or mountainous countries, they are wholly strangers, though common along the banks of all the intermediate water-courses and lagoons.

"Of their manners at the interesting period of propagation and incubation we are not yet satisfactorily informed. They nest in hollow trees, and take little if any pains to provide more than a simple hollow in which to lay their eggs, like the woodpeckers. Several females deposit their eggs in the same cavity; the number laid by each is said to be only three, which are nearly round, and of a light-greenish white.[9] They are at all times particularly attached to the large sycamores, in the hollow trunks of which they roost in close community, and enter at the same aperture, into which they climb. They are said to cling close to the sides of the tree, holding fast by the claws and bill; and into these hollows they often retire during the day, either in very warm or inclement weather, to sleep or pass away the time in indolent and social security, like the *Rupicolas*[10] of the Peruvian caves, at length only hastily aroused to forage at the calls of hunger. Indeed, from the swiftness and celerity of their aërial movements, darting through the gleaming sunshine, like so many sylvan cherubs, decked in green and gold, it is obvious that their actions as well as their manners are not calculated for any long endurance, and, shy and retiring from all society but that to which they are inseparably wedded, they rove abroad with incessant activity, until their wants are gratified, when, hid from sight, they again relapse into that indolence which seems a relief to their exertions."[11] Scansores.

The pavouan parrakeet (*Ps. Guianensis*, Lath.) belongs to our present group. This species is native to Cayenne, and the Antilles, where it is not uncommon, often flying about in flocks, frequenting the wooded savannahs, and feeding by preference on the berries of *Erythrina corallodendron*. Its length is about twelve inches, its prevailing plumage green, the cheeks and sides of the neck being speckled with bright red, which becomes more conspicuous as the bird advances in age; the smaller wing-coverts are bright red, the greater yellow, and both the quill and tail feathers are dusky yellow beneath. The bill is whitish, the legs and feet gray. We owe to M. Gabriac the following interesting particulars regarding the breeding of a pair of this species in the domestic state. Two cages were prepared for their reception in the month of April. They were placed contiguous, but communicating only by a small door, and the one enjoyed the "blessed light of day," while the other was kept covered, so that no light could enter but by the mutual door. The latter also contained an abundant supply of saw-dust. The birds were placed in the open apartment, which was the larger of the two, and they speedily showed symptoms of tender attachment to each other. They long declined, however, to enter the darkened dwelling, although the female put in her head, withdrew it again, advanced part of her body, then returned tail foremost,—but finally, after several days of hesitation, she entered the mysterious chamber. There she expressed her satisfaction by little kindly cheerful cries, and often called in the male, who exhibited every proof of affection. She soon began to scrape about, and arrange a kind of nest, and on the 18th of May she layed her first egg, succeeded at intervals of three days by a second, third, and fourth,—after which she sat assiduously. The male took no share in the hatching, but he kept constantly close by the nest, as if to cheer her sedentary hours. He did not however allow his affection to his wife to interfere with his duty to his hoped-for family. If the female, who never left the nest but to solace herself with meat and drink, appeared to devote too much time to that indulgence, he remanded her back by a little blow with his

[1] Nuttall's *American Ornithology*, vol. i. p. 546.
[2] *Hist. Nat des Perroquets.*
[3] *Cupressus disticha.*
[4] *Platanus occidentalis.*
[5] *Celtis occidentalis.* *Xanthium strumarium.*
[6] *Ambrosia, species.*
[7] *Platanus occidentalis.*
[8] Audubon, *Orn. Biog.* i. p. 139.
[9] *Cock of the rock* of Peru, which is also somewhat related, apparently, to the parrots. (Note by Mr Nuttall.)
[10] Nuttall's *Manual of Ornithology*, i. 456.

Scansores. beak, which occasionally produced something approaching to a quarrel. At the termination of twenty-five days, there being no appearance of progeny, the eggs were purposely withdrawn and broken, and were found to contain young in different stages of development, but all dead. This result was attributed to stormy weather, which had prevailed during incubation. Fortunately a second laying, accompanied by the same circumstances as the first, commenced on the 14th of July, and after twenty-three days, counted rigorously, the young appeared from each egg in a succession corresponding to the order of laying. They were at first covered by a grayish down, and were cherished with the tenderest solicitude by the parents, who on the approach of any threatened danger defended them with the greatest courage. It was in truth a curious sight to see two creatures before so kind and tenderly affectionate to those around them, so grateful for their food, and so solicitous of human kindness, converted by the strength of this new passion into little tigers, and so intractable as to attend no longer to fair hands or gentle voices. This natural wildness showed itself also strongly in the young ones, who recognised alone their parents, and bit and scratched at all the world besides.

A few species have the tail square, with the central feathers prolonged, and these in *Ps. setarius*, Temm. *Pl. Col.* 15, are bare of barbs, except at the tip.

The great mass of *parrots* properly so called, belonging to the restricted genus Psittacus, have the bill rather strong, the face clothed with feathers, the head large, without crest, the body thick, and the tail rather short and square. Green is the prevailing colour of the plumage, and the species are native to various countries both of the old world and the new. One of the best known, and most remarkable for its easy docility, the distinctness of its articulation, and general loquacious powers, is the common gray parrot, *Ps. erythacus*, of which the tail is red, and the orbits white and naked. It is an African species, and one of the earliest and most frequently imported. It has been known to breed in Europe,—a French gentleman at Marmande having had a pair which produced young ones for five or six years successively. They made their nest in spring, in a cask filled with saw-dust, the number of eggs being four, of which one was always unproductive. According to Labat a similar instance had previously occurred at Paris. Our present square-tailed group is very numerous.

The lories (genus Lorius, Vig.) have the bill rather attenuated, the upper mandible much arched, compressed, the lower lengthened, and nearly entire. The tongue is described as bristly and tubular. The tail is rather short, slightly graduated. Various shades of red form the prevailing colour of the plumage. The species inhabit the East Indies and the Asiatic islands. Example, *Ps. unicolor, garrulus*, &c.

Certain short-tailed species, of small size, which inhabit the tropical countries of both the new and old world, form the genus Psittaculus of Kuhl. Such are *Ps. passerinus, tui*, &c. They are erroneously called parrakeets by some of our English writers, a name which would confound them with the long-tailed species already alluded to, and more generally recognised under that title. The vast extent of the parrot tribe renders subdivision extremely desirable as a matter of convenience; but it must be confessed that a mere difference in size and colour is not of itself sufficient to authorize the separation of groups, or the formation of genera.

The genus Microglossus, Vieil., is, however, better founded. The bill, especially the upper mandible, is very large and strong, the head ornamented by a crest of narrow feathers, and the face naked. The tongue is cylindrical, lengthened, and tubular, capable of being greatly protruded from the mouth, and ending in a kind of corneous gland, cloven at the tip. (See Plate XIII., figures 5 and 6.) The legs are more naked than usual, and the tarsi, on which they occasionally rest while walking, very short and square. The tail is square or even. We are not acquainted with more than two species, both from eastern countries. The black or giant cockatoo (*Ps. gigas*), called by old Edwards "a parrot of the first magnitude," and *Ps. aterrimus* of Gmelin, are the birds alluded to. Their synonymy seems confused. They inhabit New Guinea and the isle of Waigiou; and Edwards's figure was taken from a living specimen in Ceylon, but whether indigenous or imported does not appear. Vaillant observes of one of the species (his *ara noir à trompe*), that in cold weather it covered the bare space on each side of its face by lowering over them the feathers of the crest. Scansores.

The great New Holland species, called the Banksian cockatoo, discovered in the course of Captain Cook's first circumnavigation, forms, with others, the modern genus *Calyptorhynchus*. (Plate XIII., figure 2.) These large dark-coloured species are as yet but ill defined. They are said to live on roots; but Mr Bennet alludes to one which feeds on the larvæ of insects, as well as on the seeds of Banksia, Hakea, and even of Xanthorrhœa, or grass tree; and in the travels of that gentleman we find the following passage, which relates to a certain locality in New Holland. "Black and white cockatoos had lately become very numerous about this part of the country: the former appeared to have been attracted by some trees that had been felled when clearing a spot of land for cultivation,—as these birds visit the dead or fallen trees to procure the larvæ of insects that breed in them. I have seen, more than once, small trees lying prostrate, occasioned by the powerful bills of the large black cockatoos, who, observing on the trunk, externally, indications of a larva being within, have diligently laboured to extract it; and should the object of their search be situated (as often occurs) far in, before they reach it the trunk is so much cut through, that the slightest puff of wind lays it prostrate."[1]

The white-plumaged cockatoos, with conspicuous crests, tinged in part with orange, red, or yellow, pertain to the genus Plycotolophus, Vieil. (Plate XIII., figure 3.) They inhabit New Holland and the eastern islands, and are remarkable for their great docility. They are said to prefer the vicinity of marshy places.

A beautiful small parrot, with longer legs than usual, and straighter claws, forms the genus Pezoporus, Illiger. It is green and yellow, spotted with black, the frontlet red, the tail long and graduated. The outer hind claw is very long. This singular bird, commonly called the ground parrot (*P. terrestris*, Shaw,—*P. formosus*, Latham), differs from its congeners in hardly ever perching upon trees. It remains upon the ground in sedgy plains, or runs among the long grass, almost after the manner of a rail. (Plate XIII., figure 4.)

At the conclusion of the scansorial order Cuvier has placed two genera which have certainly but little in common with the preceding groups, and which some consider as allied to the gallinaceous order, while others have placed them in the conirostral tribe of Passeres,—we mean Corythaix and Musophaga. In both the bill is rather short, the upper mandible bulged or rounded, the feet have a short membrane between the toes, and although these are not placed exactly in pairs, yet the outer toe is versatile to a considerable degree. The nostrils are simply pierced in the corneous portion of the bill, the margins of which are dentated. In the plantain-eaters (genus Musophaga

[1] *Wanderings in New South Wales, &c.* i. 182.

Rasores. Isert, Plate XIII., figure 8) the base of the bill forms a raised expanded disk upon the forehead. The violet plantain-eater (*M. violacea*) is a bird of great beauty, the general plumage being of a rich glossy violet black, the crown and primaries crimson, the bill yellow tipt with red, and a clear white stripe beneath the eye. It occurs in the province of Acra, in Guinea, and in other parts of Western Africa, and feeds on the fruit of the musa or plantain tree. The touracos (genus CORYTHAIX, Illiger, Plate XIII., figure 7) want the expansion at the base of the bill, and have the head adorned by an elongated crest. Several beautiful species belong to this genus, such as the *Cuculus Persa* of Linn., a native of the Cape, —of a fine green colour, with a portion of the quill-feathers crimson. Vaillant informs us that there are great numbers of these birds in the country of the Kottinquas,— that they are very difficult to shoot, as they perch only on the summits of the tallest trees, and rarely suffer any one to approach within gun-shot,—but that they are easily caught alive in snares baited with such fruits as are in season. He adds, that they are excellent eating. Another species of this genus, which it is delightful to look upon, is the Pauline touraco, *C. Paulina*, also a native of Southern Africa. M. Vieillot, who had occasion to examine one alive in Paris, informs us that its manners were mild and familiar, that it lived on succulent fruits, and was fond of sugar. Its habits were active, its voice sonorous, and apparently ventriloqual.

ORDER IV.—RASORES.[1]

GALLINACEOUS OR RASORIAL BIRDS.

The species of this order, by far the most valuable to the human race of all the feathered tribes (how many, regardless of Ornithology, yet dwell with pleasure on a roasted turkey), are characterized by a rather short and convex bill. The upper mandible is somewhat curved, and furnished with a cere, sometimes naked, sometimes feathered. The head is generally small in proportion to the body. The nostrils are placed on each side of the bill, and usually in a fleshy protecting membrane. The tarsi are for the most part elongated. The toes are four in number, three of which are anterior, and united by a membrane more or less extended, at their bases; the fourth, posterior, is articulated higher than the others, and is in some cases very small, or even entirely wanting.

This order, as we have elsewhere noticed, contains several of the most ornamental, and a great majority of the most highly prized and useful species of the feathered race. While the peacock and golden pheasant stand unrivalled alike for elegance of form and beauty of plumage, the turkey and domestic fowl, the grouse quail and partridge, lay claim to more substantial though less sentimental regard, as conducing in no small degree to the social enjoyments of civilized life. Gallinaceous birds are generally distinguished by a bulky form, and a heavy and somewhat laborious flight. In fact, the sternum or breast-bone is so deeply notched on either side as to diminish the support afforded to the action of the pectoral muscles; and the power of the wings, and consequent duration and velocity of their movements, suffer a corresponding diminution.

With the exception of the alectors or curassoes, few of the gallinaceous species build on trees (in which they differ remarkably from the preceding orders), though all delight in basking on the ground, and scraping in the dry and sultry soil, for which purpose they are provided with muscular limbs and feet. They live upon all sorts of grain and seeds,—occasionally upon berries, or the buds of shrubs and trees,—and, the younger birds especially, show themselves sufficiently eager and expert in the capture of insect prey. The females lay a great number of eggs, in a rude and carelessly constructed nest; and the newly-produced offspring, unlike the callow nestlings of the other orders, though they remain for some time associated with their parents, run swiftly, and pick freely from their first exclusion. The males, particularly towards the breeding season, are quarrelsome and courageous,—indulging in frequent and sometimes fatal contention. They are often furnished with spurs. In the satyr pheasant both sexes are so armed, and the males are moreover provided with a couple of horns. In the polyplectron the tarsi of the male are doubly armed, there being two spurs on each leg. Rasores.

In their general form and habits, the particular structure and functions of the digestive system, and the great benefits which they confer upon the human race, birds of this order have been observed to bear a considerable resemblance to the ruminating or herbivorous quadrupeds. Like these, their stomach is of a more complex character, consisting of a dilated membranous pouch or crop, and a muscular gizzard,—in the former of which their food is rendered moist and pulpy, in the latter it is bruised and broken, and otherwise prepared for the production of the life-sustaining chyle; whereas in accipitrine birds the crop is either inconspicuous or non-existent, and the stomach, if not membranous, at least has its muscular coating very thin. The intestine in gallinaceous birds is rather long and wide, of nearly uniform diameter, and provided with two enormous cæca. Their flesh, we need scarcely say, is very delicate, and highly esteemed as a pleasing and nutritious food. It varies considerably in colour,— that of the turkey and common poultry being white, of the moor grouse brownish red, while the breast of the blackcock presents two distinct layers of red and white, the one imposed upon the other. We allude at present to its *culinary* aspect.

Naturalists have erred in assigning the polygamous habit as a general characteristic of our present order The instinct to pair, or habit of monogamy, is no doubt bestowed only on those species to which it is necessary for the sustentation of their young, and differs considerably in the nature and permanence of the attachment, according as the nest is placed above or upon the surface of the ground. All birds which build on trees, as was long ago observed by Lord Kames, are hatched blind, or extremely defective in the sense of sight, and almost without feathers,—thus requiring the sedulous care of both parents. But the generality even of gallinaceous birds, which breed upon the ground, do likewise pair, though the hatching of the eggs is entirely confided to the female, who completes her task by leading the young towards their proper food, which they are able to select for themselves, being active, completely formed, and well feathered, from their first exclusion. What is indeed more beautiful than the fond affection of these devoted creatures, teaching in the blindness of instinctive love, a lesson to proud but cold humanity? Who knoweth not (now divinely told) how the hen "doth gather her brood beneath her wings;" how she shelters them from the nipping blast, expanding her downy breast and feathery pinions, till she becomes a populous tabernacle, a living temple of maternal love, beset with small protruding bills, and bright but gentle eyes; how she will dare, with upraised ruffled plumes, the fiercest onset of the direst foe,—the callous school-boy with his threatening club, the snarling cur-dog with his ivory fangs, the insidious weasel, creeping serpent-like through tangled herbage, or the bolder bird of prey, "lord of the lion

[1] GALLINÆ, Linn.

Rasores.

heart and eagle eye," descending swift and sure, like thunder-bolt from heaven! What are each or all of these in dread array, with death itself, to her at other times a fearful creature, but now pervaded by the deep intensity of mother love? Who knoweth not these things may have wandered far through wood and wilderness, up vast and lonely mountains, in moist and green savannahs, o'er dry and desert sands,—but he has never turned a kindly and considerate eye towards perhaps the too familiar features of some lowly farm-stead close by his early home. Yet to such thoughts the mind, in those that loved them once, not seldom turns. The hoary worn-out warrior, with "scars entrenched," and decked with emblems of the blood-stained field,—the smooth but hollow statesman, gorgeous on gala days in regal throngs,—the lawyer with insidious tongue, by which the worse is made the better reason,—the nabob "with visage discomposed," sallow as his gold (his heart as pure?),—the soft physician, with stilly foot and ever ready palm,—the merchant prince dreaming of "Tyre and Sidon," of freighted vessels, and "the injurious sea,"—think they not often of their boyish years, when one bright summer day seemed like a century of such delight as all their best planned schemes of proud ambition since then have yielded never? But in these fantastic thoughts forget we not our *gallinaceous order?*

The male, though somewhat less assiduous than the female, continues to manifest a certain degree of parental solicitude, by uttering the alarm note on the approach of birds of prey, or other dangerous foes. Black game and wood grouse, however, do not seem to pair at all, but in the genial spring a male assembles round him a certain number of devoted females, which afterwards deposit their eggs, and rear their young altogether independent of the male parent. These birds are therefore polygamous in the proper acceptation of the term. Indeed, even among herbivorous quadrupeds pairing is rare, because the female can suckle her young while she herself is feeding;—but the monogamous habit probably obtains among most carnivorous quadrupeds, and certainly among all carnivorous birds, because incubation leaves the female no sufficient time to hunt for food,[1] and because young birds cannot bear a long fast, and therefore require the assistance of both parents while unable to provide for themselves.

An extraordinary circumstance has been observed in the females of certain genera of this order, viz. an assumption of the male plumage after a certain period of life. We believe it to be a fact in the natural history of common poultry, that all hen-birds which either by accident or design have been allowed to attain the age of sixteen years complete, have been observed to assume the plumage of cocks! The same change has been seen to take place both in the female pheasant and the pea-hen, but at more indeterminate periods of life, and less in connection with an advanced age. Though these facts have not escaped the observation of the philosophical naturalist, yet the different circumstances attending their occurrence have not been detailed with sufficient frequency or fulness to admit of any satisfactory theory being offered in their explanation.[2] We shall conclude these general remarks by observing, that the gallinaceous order, with the exception of the pigeon tribe, and the genus *Opisthocomus* (*Hoazin*, Buffon), which certainly offer some very anomalous characters, is naturally and consistently composed. We shall now proceed to a brief notice of the principal genera.

The birds known by the general name of *Alectors* are species of large size from South America, somewhat allied to turkeys. Their tails are broad and rounded, and composed of large stiff feathers. They inhabit woods, living on fruits and buds, perching and building their nests on trees, and dwelling gregariously in love and amity. They are known under the by no means euphonious names of *hoccos* and *jacous* (words which we shall not pronounce except when necessary), and are arranged as follows by Baron Cuvier. The hoccos properly so called, which are also known as curassoes (genus Crax, Linn., Plate XIV., fig. 1), have the bill strong, and its base surrounded by a skin sometimes of lively colour, and containing the nostrils. The head is ornamented by a tuft of long, narrow, recurved feathers. The most common kind is the *Crax alector*, or crested curasso, which was at one time almost completely acclimated in Holland, where they were as prolific as common poultry. It is so frequent in the woods of Guiana as to form, according to M. Sonnini, the surest resource of every hungry traveller whose stock of provisions may be found exhausted, and who has therefore become dependent on his gun. They are gregarious, and even when a considerable number have been shot, the rest will remain quietly perched, as if unconscious of the surrounding slaughter. Several other species are described in systematic works. *C. globicera* is distinguished by a large rounded tubercle on the base of the upper mandible.

Rasores.

In the genus Ourax, Cuv., the bill is shorter and thicker, with its basal membrane, as well as the greater portion of the head, covered with short, velvety feathers. (Plate XIV., figure 2.) Here is placed the *Ourax pauxi* (*Crax pauxi*, Linn.), or galeated curasso, a large turkey-like bird, with plumage of a shining black with green reflections, the abdomen and under tail-coverts white. At the base of the beak is a great oval tubercle, of a pale blue colour, and as hard as stone. The structure or position of the windpipe is peculiar. "Sa trachée," says Cuvier, "descend dehors, le long du côté droit jusqu'en arrière du sternum, se recourbe vers le côté gauche, et revient en avant pour rentrer dans la poitrine par la fourchette. Tous ces anneaux sont comprimés." This species is a native of Mexico, where it lives gregariously, perching on trees, but building usually on the ground, and leading about its young after the manner of the pheasant and common hen. It is easily domesticated.

The guans or yacous, genus Penelope of Merrem, have the bill more slender than the preceding, with a bare space around the eye, and on the lower part of the throat,—the latter generally capable of inflation. The individuals of the same species seem to vary considerably, so that many doubtful kinds have been described by naturalists. The guan, commonly so called (*Pen. cristata*, Gmelin), is the largest of the genus, measuring about thirty inches in total length. The whole upper surface of the body is of a dusky black or bronze colour, glossed with green and olive. The feathers on the back of the head form a thick erectile crest. The fore part of the neck and breast are spotted with white, each feather being surrounded by a white border. The naked part of the throat is bright scarlet, with a depending fold of the same colour. The manners of this bird resemble those of the curassoes. They search for food along the ground, but perch and build upon the tops of trees. They are less gregarious, generally keeping together in pairs, and remarkable, it is said, for the strictest constancy, and their strong attachment to each other,—being thus deserving of the name they bear, that of the devoted consort of Ulysses.

The genus Ortilda of Merrem scarcely differs from the preceding, except in having a much smaller portion bare around the eye and throat. We are acquainted with only a single species, the *Phasianus motmot* of Gmelin (*Phas. parragua*, Lath.). Its voice is very strong, and the windpipe descends beneath the skin towards the abdomen, and then remounts into the chest. The plumage is of a bronzed

[1] See Kames's *Sketches.*

[2] Wilson's *Illustrations of Zoology*, vol. i. Order Gallinæ.

Rasores. brown above, and ashy-white below, the crest red. It inhabits Brazil, Paraguay, and Guiana. Two other species are described by M. Lesson, *Ort. Goudotii* and *squamata*,—the former inhabits the mountains of Santa Fé de Bogota, the latter is native to Brazil.[1]

The genus Opisthocomus of Hoffmansegg (*Sasa* of Vieil.) is associated in our present system with the preceding alectors. The only known species (*Phasianus cristatus*, Lath.) has the bill short and thick, the nostrils pierced in its corneous portion, without the usual surrounding membrane. The head bears a crest of long, slender, decomposed feathers, and the toes (in which character it also differs from all the genuine gallinaceous kind) have no connecting membrane at the base. The bird occurs in Guiana, where it is usually seen perched in places subject to inundation. It lives chiefly on the leaves and seeds of a species of arum. Its flesh has a strong smell of castoreum, and is used only as a bait for fishes. "Il forme," says Baron Cuvier, "un genre très distinct des autres gallinacées, et qui pourra devenir le type d'un famille particulière quand on connaitra son anatomie."[2] Its true situation in the natural system seems at present quite uncertain, but, from its great diversity in different works, must assuredly in some be most erroneous.

In the genus Pavo of Linn., the bill, of moderate size, is bare at the base, the nostrils lateral, sub-basal, open. The head is crested, the cheeks are naked, or nearly so. The tarsi are rather long, and armed with a conical spur. The upper coverts of the tail are of singular length and magnificence. The tail itself is erectile and wedge-shaped. The wings are rather short. This genus, as now restricted, contains only two species. The common peacock (*Pavo cristatus*, Linn.), so much admired for the surpassing splendour of its plumage, and now so familiarly known as a domestic bird, has probably been reduced to a state of dependence, if not of servitude, for some thousand years. The earliest notice we possess of it is contained in the second book of Chronicles. "For the king's ships went to Tarshish with the servants of Hiram: every three years once came the ships of Tarshish, bringing gold, and silver, ivory, and apes, and peacocks." The introduction of this beautiful bird to the western countries of Europe has never been clearly traced,—but every step of its progress has no doubt been owing rather to the agency of man than the instinct of nature. Its inborn tendency would clearly have been to return to whence it came,—to seek again the perpetual sunshine, and ever-verdant forests of Asia, the banks "of Ganges or Hydaspes, Indian streams." It appears to have been unknown even in Greece during the early manhood of Alexander the Great, by whom it was first observed with no less wonder than delight in the progress of his southern expedition, and then transmitted to his native country. There, however, it must have multiplied speedily, as Aristotle, who died in a year or two after "the great Emathian conqueror," mentions the peacock as a well-known bird. It is now distributed among most civilized nations, beautifying with lustrous train our verdant lawns, and arching its proud emblazoned neck among the "ancestral trees" of many lordly dwellings. The cry of the peacock, unless when mellowed by distance. is harsh and unmusical, but extends far and wide. Indeed the notes of all birds, whether musically toned or inharmonious, are very clear and forcible. The voice of a blackbird may be heard as far as that of a man,—the clanging cry of the stork has been calculated to fill a circumference of nearly half a league, and the harsh scream of the peacock extends as far as that of an elephant.[3] Mr Waterton observes, that the singular metallic note of the campanero or bell-bird of America is audible from a distance of three miles. Rasores.

The only other species of this genus (as now restricted) is the Japan or Javanese peacock (*P. Japonensis*, Briss.,—*P. Javanicus*, Horsfield), of which we have elsewhere figured both the adult male and young, under the name of Aldrovandine peacock, from the specimens in the Edinburgh Museum.[4] It occurs in Japan, Java, and other eastern and southern regions of Asia. The particular markings and general distribution of the colours in the train scarcely differ from those of the better-known species; but the Aldrovandine bird may be distinguished at first sight from the common kind, by a difference in the form, colour, and consistence of the cervical feathers; by the shape and structure of the occipital crest, of which the plumes are lance-shaped, or broadly linear, and barbed throughout their entire length, instead of being merely tufted at the extremities; by the dissimilar plumage of the wing-coverts, and the number of feathers in the tail, which in the former consists of twenty, in the latter of only eighteen.

The genus Polyplectron, Temm., contains a few species formerly classed with the preceding, but of smaller size, and distinguished by a pair of spurs on each tarsus. Such is the beautiful Thibet peacock (*Pol. Thibetanus*), the peacock-pheasant of Edwards, of which a great proportion of the plumage is ornamented by large and very brilliant spots of greenish blue, changing with the varying light to gold and purple, and surrounded by circles of black and yellowish white. The male is about the size of the golden pheasant. The plumage of the female is less brilliant, and her tail shorter. The colour in the young of both sexes is earthy gray, with large spots and small lines of brown. This species is of easy domestication, and not remarkable for shyness even in a state of nature. It is native to the mountains of Thibet, and is said also to occur in China. At least it is frequent in the aviaries of that leaf-soaking people.

The genus Lophophorus, Temm., distinguished by its tufted hanging crest, and strongly bent and broadly margined bill, contains that splendid bird the Impeyan pheasant (*Loph. refulgens*), of which the colours of the plumage are so exceedingly brilliant from their metallic lustre, and so variable according to the direction of the light or the position of the spectator, that they cannot be expressed by words, and even the skill of the most accomplished painter would in vain attempt to equal the bright original. Purple, green, and gold, are the prevailing hues. The female, however, is almost entirely destitute of metallic splendour. This bird inhabits the mountains in the northern parts of Hindustan. Lady Impey endeavoured to transport it alive to England, but it died on the passage. It is known to the natives by the name of *monaul*, which signifies the bird of gold.

The genus Meleagris, Linn., distinguished by its bare and wattled head and neck, and broad erectile tail, contains the valuable but unromantic turkey, *M. gallo-pavo*, Linn., a heavy and ungraceful bird, as it exists in the poultry-yards of Britain, but of a richer plumage and more powerful wing in its native wooded wilderness. "The wild turkey," observes Mr Nuttall, "once prevalent throughout

[1] *Dictionnaire des Sciences Nat.* t. lix. p. 195.

[2] *Règne Animal*, t. i. p. 473, note.

[3] We have few opportunities (fortunately) afforded us in this country of judging of the strength of voice in wild beasts. Our own experience extends only to the following homely fact, which, however, it may be worth while to mention. During the residence in Edinburgh of Mr Wombwell's and other travelling menageries, we have endeavoured to test the extension of the lion's voice from different quarters. We have often heard it very distinctly on a still evening, about feeding time, from the top of Craigleith quarry, distant from the menagerie (on the Mound, Princes Street) about two miles and a half.

[4] *Illustrations of Zoology*, vol. i. pl. 14, 15.

 the whole continent of North America, from Mexico and the Antilles to the forests of Lower Canada, is now, by the progress and density of population, chiefly confined to the thickly wooded and uncultivated tracts of the western states, being particularly abundant in the unsettled parts of Ohio, Kentucky, Illinois, Indiana, and throughout the vast forests of the great valleys of the Mississippi and Missouri. On the banks of the latter river, however, where the woods disappear beyond the confluence of the Platte, the turkey no longer appears, and the feathers of the wings, for the purpose of pluming arrows, form an article of small commerce between the other natives and their western countrymen. For a thousand miles up the Arkansas and Red River, in the wooded alluvial lands, they are not uncommon. They are likewise met with in small numbers in Tennessee, Alabama, and West Florida. From the Atlantic states generally they are now nearly extirpated. The wild turkey is neither gregarious nor migratory, but from the necessity of wandering after food; it is otherwise resident throughout the whole of the vast region it inhabits, including the greatest diversity of climate; and it is prolific in proportion to its natural resources, so that while in the United States and Canada it only breeds once in the year, in Jamaica and the other West India islands it is said to raise two or three broods in the same period. In quest of mast, they therefore spread themselves through the country, and insensibly assemble in considerable numbers to the district where their food abounds. These movements are observed to take place in October (the turkey moon of the aborigines). The males, or *gobblers* as they are often called, from their note, are now seen apart from the other sex, in companies varying from ten to a hundred. The females move singly, or accompanied by their almost independent brood, who all at first shun assiduously the persecuting society of the selfish male. Yet after a while, when their food proves abundant, separate mixed flocks of all ages and sexes often promiscuously join in the bounteous repast. Their migration, very unlike that of the rapid pigeons, is made almost entirely on foot, until their progress is perhaps arrested by a river. Their speed, however, is very considerable, and when surprised, they more commonly trust to their legs than their wings, running nearly with the velocity of a hound. On meeting with an impediment of this kind, after considerable delay, they ascend to the tops of the tall trees, and, at the cluck of the leader, they launch into the air for the opposite shore. The transit is a matter of little difficulty, though considerable labour, for the older birds; but the younger and less robust sometimes fall short of the bank, and are either drowned or attain the land by swimming. After crossing, it is remarked that they often become an easy prey to the hunter, as they seem bewildered by the new country in which they have arrived, or more probably are fatigued by the novelty and extent of their excursion. After long journeys and privations, particularly in frosty weather, or while the ground is covered with snow, they are sometimes reduced to the necessity of making their appearance near farm-houses, where they now and then even associate with the poultry, and enter the stables and cribs after grain. In this desultory and foraging manner they spend the autumn and winter.

"According to the latitude, and the advancement of the season, though always very early in the spring, they begin to be actuated by the instinct of propagation. The males commence their gobbling, and court the society of their retiring mates. The sexes roost apart, but in the same vicinity, and at the yelp of the female the gobbling becomes reiterated and extravagant. If heard from the ground, a general rush ensues to the spot, and whether the hen appears or not, the males, thus accidentally brought together, spread out their train, quiver and depress their rigid wings, and strutting and puffing with a pompous gait, often make battle, and directing their blows at the head, occasionally destroy each other in a fit of jealousy. As with our domestic fowls, several hens usually follow a favourite cock, roosting in his immediate neighbourhood, until they begin to lay, when they withdraw from his resort to save their eggs, which he would destroy if discovered.

"The females are therefore seen in his company only for a few hours in the day. Soon after this period, however, the male loses his ardour, and the advances of affection now become reversed, the hen seeking out the society of her reluctant mate. In moonlight nights the gobbling of the male is heard, at intervals of a few minutes, for hours together, and affords often a gratifying means of their discovery to the wakeful hunter. After this period the males become lean and emaciated, so as to be even unable to fly, and seek to hide themselves from their mates in the closest thickets, where they are seldom seen. They now also probably undergo their moult, and are so dry, lean, and lousy, until the ripening of the mast and berries, as to be almost wholly indigestible, and destitute of nutriment as food. So constant is this impoverished state, that the Indians have a proverb, 'As lean as a turkey in summer.'

"About the middle of April, in Kentucky, the hens begin to provide for the reception of their eggs, and secure their prospects of incubation. The nest, merely a slight hollow scratched in the ground, and lined with withered leaves, is made by the side of a fallen log, or beneath the shelter of a thicket, in a dry place. The eggs, from ten to fifteen, are whitish, covered with red dots. While laying, the female, like the domestic bird, always approaches the nest with great caution, varying the course at almost every visit, and often concealing her eggs entirely by covering them with leaves. Trusting to the similarity of her homely garb with the withered foliage around her, the hen, as with several other birds, on being carefully approached, sits close without moving. She seldom indeed abandons her nest, and her attachment increases with the growing life of her charge. The domestic bird has been known not unfrequently to sit stedfastly on her eggs until she died of hunger. As soon as the young have emerged from the shell, and begun to run about, the parent, by her cluck, calls them around her, and watches with redoubled suspicion the approach of their enemies, which she can perceive at an almost inconceivable distance. To avoid moisture, which might prove fatal to them, they now keep on the higher sheltered knolls; and in about a fortnight, instead of roosting on the ground, they begin to fly at night to some wide and low branch, where they still continue to nestle under the extended wings of their protecting parent. At length they resort during the day to more open tracts, or prairies, in quest of berries of various kinds, as well as grasshoppers and other insects. The old birds are very partial to pecan-nuts, winter grapes, and other kinds of fruits. They also eat buds, herbs, grain, and large insects; but their most general and important fare is acorns, after which they make extensive migrations. By the month of August the young are nearly independent of their parent, and become enabled to attain a safe roost in the higher branches of the trees. The young cocks now show the tuft of hair upon the breast, and begin to strut and gobble, and the young hens already pur and leap. One of the most crafty enemies which the wild turkey has to encounter is the lynx or wild cat, who frequently seizes his prey by advancing round, and waiting its approach in ambush. Like most other gallinaceous birds, they are fond of wallowing on the ground, and dusting themselves.

"When approached by moonlight, they are readily shot from their roosting-tree, one after another, without any

Rasores. apprehension of their danger, though they would dodge or fly instantly at the sight of the owl. The gobblers, during the season of their amorous excitement, have been known even to strut over their dead companions while on the ground, instead of seeking their own safety by flight. In the spring, the male turkeys are called by a whistle made of the second joint bone of the wing of the bird, which produces a sound somewhat similar to the voice of the female; and on coming up to this call they are consequently shot. They are likewise commonly caught in quadrangular pens made of logs crossing each other, from which is cut a slanting covered passage sufficient to allow the entrance of the turkey. Corn is then scattered in a train to this cage for some distance, as well as within; and the neighbouring birds, in the surrounding woods, having discovered the grain, call on each other by a clucking, and entering one at a time, they become secured in the pen, as, for the purpose of escape, they constantly direct their view upwards, instead of stooping to go out by the path by which they had entered. The male wild turkey weighs commonly from fifteen to eighteen pounds, is not unfrequently as much as twenty-five, and sometimes, according to Audubon, even thirty-six. The hen commonly weighs about nine pounds; and the usual price for a turkey from the Indians is twenty-five cents."[1]

The only other species of turkey is a very rare and beautiful bird (*M. ocellata*, Cuv.), of which, we believe, only a single specimen is yet known. It was captured by the crew of a vessel who were cutting wood in the Bay of Honduras, and was brought alive to the Thames, for presentation to Sir Henry Halford, but met with an accident which caused its death. It afterwards became the property of Mr Bullock; and on the dispersion of his collection, was purchased by the French government for the Paris Museum. It is nearly equal in size to the common turkey. The tail is less ample, but its colours are more varied and beautiful, almost rivalling those of the peacock in its little mirrors of sapphire, surrounded by circles of gold and ruby.[2]

The species known to us by the name of Guinea fowls, form the genus NUMIDA, Linn. The head is bare, the top in some crested, and the throat wattled. They are all either from Africa or Madagascar.

The great genus PHASIANUS, Linn., including our cocks and pheasants, has the cheeks more or less bare of feathers, usually covered by a scarlet skin, and the tail-feathers so placed as to slope downwards, roof-like, from either side. The group was soon found to be too extensive and varied in its component parts to accord with the preciser views of modern times, and several subdivisions have been in consequence effected.

The restricted genus GALLUS, for example (Plate XIV., figures 3 and 3 *a*), of which the head is generally surmounted by a fleshy vertical crest, the base of the lower mandible furnished with two flattened wattles, and the tail-feathers, fourteen in number, rising in two almost upright planes, with ample coverts in the male sex, contains, among other remarkable species, our domestic *cock and hen* (*Gallus domesticus—Phasianus gallus*, Linn.). The general attributes or special qualities of this brave, vigilant, and invaluable species, need not be here recorded; and indeed a volume would scarcely suffice to describe its numerous variations, from the pure undaunted blood of Derby, fearless of death, to the crested dung-hill breed, almost equally pugnacious, and by no means cowardly, yet apt to turn tail on the sudden touch of unexpected steel.

In our present paragraph we avail ourselves in part of a recent brief compendium. The cocks with ample crests, and five toes,—the rumpless cock, and those of many-mingled colours,—appear to have arisen chiefly from the various and prolonged circumstances attending domestication, and the intentional crossing of the breeds. The most picturesque are those with superabundant crests, and full auricular plumes. The crest is composed of narrow, hackled feathers, which grow erect from the head, but fall down in graceful curves, sometimes of such length as to shadow or overhang the eyes. In some districts this breed is much cultivated, being esteemed in proportion as the colours of the body and crest can be made to form the most conspicuous contrast, the body black, the crest white, and *vice versa*. Other admired fancy breeds are the Dutch pencilled fowl, which are pure white, with black spots; the Siberian fowl, with long tufts of hanging feathers springing from the lower jaw; and the Barbary fowl, of a pale dun colour, with the feathers of the neck extremely ample, and spotted with black. But a more singular anomaly is exhibited by those with five toes, commonly called *dorkings*, from being bred in most abundance in the neighbourhood of Dorking, Surrey. This race is easily continued, and is much esteemed for the table, being white and large. Dr Latham records one which weighed nearly fourteen pounds. A still more remarkable race is that without a tail, the rumpless or Persian cock, as it is sometimes called, which actually wants a portion of the caudal vertebræ. These are usually regarded as mere varieties, for the most part, probably, of accidental origin. There are, however, three races of cocks, of a very marked character, although their claim to actual specific distinction cannot be yet made out. The first is *Gallus morio*, of which the periosteum of the bones is black, and the comb, wattles, and skin, of a dull purple. It has received the name of negro or blackamoor cock, but is scarcely ever seen in the poultry-yards of this country. The other two races are more frequent, and are known as the silky cock (*G. lanatus*), and the Friesland cock (*G. crispus*). M. Temminck is inclined to regard the former as a distinct species. It occurs in China and Japan, where it is sold as a rarity to Europeans. In this country it crosses easily with the white domestic breed, and a mixed race is produced with the feathers still silky, but less disunited. It is singular that the skin and periosteum of this kind are of the same sable hue with those of *G. morio*, although the flesh is remarkable for its whiteness. The size is rather small, the plumage of the purest white, the comb and wattles purple. The Friesland cock evidently belongs to the opposition, having all the feathers turned the wrong way, or standing nearly at right angles with the body. The general colour of the plumage of this kind is also white, but it varies like that of other captive races. It occurs in the domesticated state in Java and Sumatra; but M. Temminck thinks it is also a distinct species, peculiar in the wild state to some unexplored quarter of the Indian islands.[3] We doubt that nature, in her first intent, should ever have produced such an oddity.

Many fanciful and superstitious feelings are still maintained regarding the domestic cock, and his nocturnal crowing; and even his more familiar morning salutation is supposed to dispel all spirits, "whether in sea or fire, in earth or air."

> Some say that ever 'gainst that season comes
> Wherein our Saviour's birth is celebrate,
> The bird of dawning singeth all night long;
> And then, they say, no spirit walks abroad;
> The nights are wholesome; then no planets strike;
> No fairy takes, nor witch hath power to charm;
> So hallowed and so gracious is the time.

[1] *Manual*, vol. i. p. 640.

[2] *Mém. du Muscum*, vi. pl. 1; and *Pl. Col.* 112.

[3] *Naturalist's Library*, vol. iii. p. 173.

Rasores. Of the numerous benefits which the goodness of God has enabled man to derive from the wide circle of the feathered race, there is probably none which surpasses, either in extent or utility, the domestication of these most familiar birds. Of so long standing, however, has been the subservience of the race to man, that no authentic traditionary traces now remain of its original introduction to any of the more ancient kingdoms of the earth,—its existence under human guardianship seeming indeed coeval with the most antique records. It may therefore be regarded as one of those particular and providential gifts, which, like the faithful and accommodating dog, was at an early period of the world added to the fortunes of the first families of the human race, and has since followed man in his wonderful and far-spread migrations through every clime and country. For some thousand years the observers of nature were ignorant of any wild species which, even in a remote degree, resembled any variety of the domestic breed,—and from the era of Herodotus to that of Sonnerat, the domestic cock and hen might have been regarded as birds, the living analogues of which were no longer known to exist in a natural and unsubdued condition.

In consequence of the remote obscurity in which the subject is thus involved, few points in natural history have occasioned more inconclusive speculation, or are even now more difficult to solve with certainty, than the source from which we have primarily derived our different races of domestic poultry. That they came originally from Persia, has been inferred from the circumstance of Aristophanes calling the cock "the Persian bird." Such an origin, however, is improbable, when we consider that the researches of modern travellers, and indeed of all who have visited that country since the revival of learning, have failed to discover there any species of wild poultry,—no gallinaceous bird being found in Persia more nearly allied to the genus Gallus, than a species of *Lophophorus*. If, however, it is merely meant that the Greeks, during the intercourse, hostile or otherwise, which existed between them and the Persian nation, may have obtained a breed previously domesticated, the idea is less objectionable; for it is known that in a domestic state poultry have existed in Persia from a very remote antiquity.

It appears from an ingenious dissertation by the late Dr Scot of Corstorphine, to have been the opinion of that learned Hebraist, that poultry were unknown to the Jews, or at least that they are not distinctly alluded to in the Old Testament. It cannot, however, admit of a doubt, that they were well known over many parts both of Europe and Asia for several hundred years before the Christian era. When Themistocles took the field to combat the Persians, he alluded, while haranguing his troops, to the invincible courage of the feathered biped. "Observe with what intrepid valour he fights, inspired by no other motive than the love of victory; whereas you have to contend for your religion and your liberty, for your wives and children, for the tombs of your ancestors;" and it was on this occasion that the Athenians achieved one of the most memorable victories recorded in history. According to Ælian, it was in commemoration of this signal event, and of the *ornithological* image by which the courage of the soldiery had been excited and sustained, that the Athenians instituted those annual games of which cock-fighting formed so conspicuous a feature. Now Themistocles died in the sixty-fifth year of his age, and about the 449th year preceding the Christian era, and must consequently have been contemporary with Nehemiah the prophet; and as the Old Testament history does not conclude till about twenty years after the death of Themistocles, it may be inferred, that if the later of the sacred historians do not mention poultry, it must be from some other cause than ignorance of their existence,—seeing that as the early Greek nations had received them prior to that period, either from Persia or the more south-eastern countries of Asia, they could scarcely have remained unknown in the *intermediate* regions inhabited by the Jews. For these and other reasons, which it would here be tedious to detail, we do not agree with Dr Scot. Rasores.

In regard to the natural origin of these domestic birds, the first approximation to the truth (and we deem it but an approximation) resulted from the discovery by Sonnerat of a species of wild poultry native to the mountains of the Ghauts, in India. This is the *Gallus Sonneratii* of systematic naturalists, better known to British residents by the now familiar name of *jungle-cock*. Our knowledge of gallinaceous birds, however, has so greatly increased during recent years, and so many additional species have been discovered, that we are able to proceed upon much more certain ground than were the naturalists of the last century. The jungle-cock is not only no longer the only claimant to the long dormant title which, under whatever name of honour, may be due to the species so greatly beneficial to the human race, but other aspirants have come forward with such better-founded claims, that his may fairly be regarded as altogether set aside. In fact, several important characters of the jungle-cock have never been traced in any of the domestic varieties, and many of these latter present features which, if not incompatible with, at least bear no resemblance to any attributes of the supposed original. We may here observe, that the natural *form* and *structure* of any portion of the animal organization are much less easily effaced or altered than the more superficial character of *colour*; and hence, if a particular species of bird be naturally distinguished by a peculiar consistence as well as colour of plumage, the influence of those causes which produce variation less frequently affect the former than the latter. Reasoning therefore *a priori*, it would be more natural to expect that if the jungle-cock were the parent of our domestic breeds, such breeds, however they might vary in the colouring of their plumage, would at least at times exhibit those marked and peculiar characters of form and structure by which the feathers of the supposed original are distinguished. This, however, is not the case. Amid the infinite varieties which occur among our domestic poultry, the plumage of none is found characterized by those horny laminæ, or expansions of the shaft, which form so marked a feature in the plumage of the jungle-cock, and which assuredly would have either continued a permanent feature, or been occasionally manifested in one or other of our domestic breeds, had these been derived from the species in question. We may mention another circumstance on which we believe we were ourselves the first to insist.[1] The native tribes of Indians inhabiting the districts where the jungle-cock abounds rear a breed of poultry which differs as much from the supposed original as our own, and which never intermingles with the forest brood.

According to M. Temminck (and in this we quite agree with that industrious and observant naturalist), the species to which our domestic races are most nearly allied, are the *Jago cock* of Sumatra (*Gallus giganteus*), a wild species of great size, and the *Bankiva cock* of Java, another primitive species, which occurs in the forests of the last-named island (see Plate XIV., figures 3 and 3 *a*.) There are several circumstances which render the claims of these two birds much stronger than those of the jungle-cock. 1*st*, Their females bear a strong resemblance to our domestic hens; 2*dly*, the common village cock, in its most ordi-

[1] See our Essay "On the Origin of Domestic Poultry," in the *Wernerian Memoirs*, vol. vi. p. 402.

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nary condition, is intermediate, in respect to size, between these two species; 3*dly*, the nature of the plumage, which in its form, consistence, and distribution, is absolutely the same as in the common cock, greatly strengthens the supposition; 4*thly*, it is in these species alone that we find the females, as well as males, provided with a fleshy crest and small wattles,—characters which likewise distinguish both sexes of our common poultry, although they are for the most part but slightly developed in the females. Now the female jungle-cock possesses neither comb nor wattles.

It may be stated as a curious though well-known fact, that when Captain Cook first visited the South Sea Islands, he found them well stocked with domestic poultry; and the more recent as well as more ample narratives of the missionaries have confirmed the statements of the great navigator regarding the practice of cock-fighting in Otaheite, and other islands of Polynesia. Mr Ellis describes the *Faa-ti-to-raa-moa*, or literally the causing fighting among fowls, as the most ancient game of the Tahitians; and he informs us, that according to the tradition of the natives, poultry have existed in the islands as long as people,—that they either came with the first colonists, or were produced by Taaroa contemporaneously with men. Long before the first foreign vessel was seen off their shores, they were in the practice of training and fighting cocks. However, they never trimmed, as we do, their flowing plumes, but were proud to see the beautiful and gorgeous combatants with ample natural wings, full-feathered necks, and lengthened tails. We may observe, that the breed of these islands do not appear to have been what in this country we would denominate *game*; for Mr Ellis (in his *Polynesian Researches*) incidentally mentions, that as soon as one bird *avoided* another, he was considered as *vi*, or beaten, and victory was declared in favour of his opponent. It is indeed a singular circumstance that this barbarous practice should have pervaded so many unconnected nations, both savage and civilized. It has entirely ceased among the inhabitants of the Friendly and Society Islands since the establishment of Christianity, although still pursued by the practical heathen of other and more ancient Christian lands. We ourselves, to our shame be it spoken, once fought a main of cocks with an English clergyman who afterwards rose to a high and conspicuous station in the church. We believe, indeed, that he became a bishop,—haply forgetful of us and of our famous *Faa-ti-to-raa-moa*.

In the genus Phasianus properly so called, the sides of the head around the eyes are covered for a space by a naked warty skin. The tail is very long and slender, each feather laterally inclined or roof-shaped, and the central pair usually much prolonged. The common pheasant of our coverts (*Ph. colchicus*) is the most familiar example. This bird is now well known in most of the temperate parts of Europe, though originally introduced from the banks of the Phasis (now the Rioni), a river of Chalcis in Asia Minor. Need we describe his glowing bright attire?

> Splendid his form, his eyes of flaming gold
> Two fiery rings of living scarlet hold;
> His arching neck a varying beauty shows,
> Now rich with azure, now with emerald glows.
> His swelling breast with glossy purple shines,
> Chesnut his back, and waved with ebon lines;
> To his broad wings gay hues their radiance lend,
> His mail-clad legs two knightly spurs defend.

The variety called the ring-pheasant (*Ph. torquatus*), characterized by a more or less completed circle of white around the lower portion of the neck, is by some regarded as a distinct species. The gold and silver pheasants of our aviaries (*Ph. pictus* and *nycthemerus*), and several other still more magnificent birds, on the beauty of which we regret we cannot here dilate, pertain to our present genus.

Rasores.

One of the most singularly superb of all the gallinaceous order, we mean the argus pheasant, now forms a separate genus under the name of Argus. Of this rare and remarkable bird (*A. giganteus*, Temm.) China and the adjoining provinces of Tartary have been assigned as the native country by various writers. This, however, requires confirmation, as all the specimens of which the origin is accurately known have been brought from the great eastern islands and peninsula of Malacca. There is a passage in Marco Polo's *Travels*, which may perhaps be construed as relating to the bird in question. In his description of the kingdom of Erginal (a district of Tangout, in the northwest of the empire), he observes, "pheasants are found in it that are twice the size of ours, but something smaller than the peacock. The tail-feathers are eight or ten palms in length." "This," observes Mr Marsden, the learned editor of the English edition, "is probably the Argus pheasant, which although a native of Sumatra (where I have frequently seen it alive), is said to be also found in the northern part of China."[1] Though of late years well known in the *Basses-cours* of Batavia (from which M. Temminck received a splendid series), we are not aware that the Argus has been ever imported alive into Europe. It would certainly prove a more magnificent addition than any which has been made to our aviaries in modern times. The great apparent size of this bird arises chiefly from the peculiar formation of the wings, of which the secondaries are three times the length of the primaries, being nearly three feet long. In consequence of the unwieldy extent of that portion of the wing which is not under the immediate influence of muscular action, this magnificent bird is alleged to be almost destitute of the power of flight. Its progress, however, when running on the ground, is greatly accelerated,—the expanded secondaries, according to M. Temminck, acting as powerful and capacious sails, and furnishing a very fleet and effectual mode of transportation. The body, when stripped of the feathers, scarcely exceeds that of a barn-door fowl, but in its "high and *plumy* state" it measures in total length about five feet three inches,—the tail-feathers being themselves nearly four feet long. The female is, as usual, less adorned. Her secondaries want the peculiar breadth and extension, as well as the beautiful eye-like markings which adorn the male. In consequence, however, of this homely appearance, she is less frequently sought for in her native forests, and is thus (in collections) by far the rarer of the two. M. Temminck, for example, thought himself fortunate in finding a brace of females among thirty males.

In the genus Euplocomus, Temm., the head is crested, the tail much broader than in the true pheasants, and sometimes forked. The beautiful Macartney cock, or fire-backed pheasant (*Eu. ignitus*), is the most characteristic, if not the sole example. It was met with by Sir George Staunton in a menagerie at Batavia, and is believed to be a native of Sumatra.[2]

The horned pheasant of Edwards and Latham has been made by Cuvier to constitute the genus Tragopan. The head, though crested, is elsewhere almost naked; a little slender horn projects backward from behind each eye, and a loose and pendent skin, inflatable at pleasure, hangs from the base of the lower mandible (see Plate XIV., fig. 4). The group now consists of about four species, all remarkable for their richly varied and beautifully spotted plumage. They are bulkier birds than pheasants, with rounded tails of ordinary length. The females of such as are known are brindled with brown and black. We have yet learned nothing of the habits or natural economy of the Tragopans, although their external aspect has been rendered familiar in elegant representations by Mr Gould.[3] The

[1] *Travels*, pp. 225–9. [2] *Embassy to China*, pl. xiii. [3] *Century of Birds from the Himalaya Mountains.*

Rasores.

first discovered species (*T. satyrus*), though usually brought from Nepaul, has been ascertained also to inhabit Thibet; and Chinese specimens from the mountain province of Yunnan were seen by Mr Bennet in Mr Beale's aviary at Macao.[1]

The genus CRYPTONYX, Temm., has a bare space around the eye, the tail of medium size and flat, and the tarsi without spurs; but the most peculiar character consists in the hind toe being destitute of claw. The best-known species is *C. coronatus*, or *roulroul* of Malacca (see Plate XIV., figure 5). The female is described by Latham under the title of *Tetrao viridis*. It inhabits deep forests, is wild and cunning in a state of nature, and in confinement impatient of restraint.

The great genus TETRAO of Linn. has also been greatly subdivided in recent times. All the species seem to agree in having a bare band above the eye.

The restricted genus TETRAO has the legs covered with feathers, and without spurs. In some the toes are naked, and the tail either forked or rounded. Such is the great wood grouse or capercailzie (*T. urogallus*), the largest and finest example of the gallinaceous order indigenous to Europe. In Britain it has been long extinct in the wild state (although of late several times imported with a view to re-establish the breed), and now occurs chiefly in Scandinavia, although not unknown among mountainous and woody regions southwards, as far as the Alps of Savoy and the Veronese. Although rather difficult to rear in Britain, the capercailzie is often domesticated in Sweden, where it becomes so tame as to eat familiarly from the hand. Though naturally shy and wary, they sometimes, even in their unreclaimed condition, manifest a singular and unaccountable degree of boldness. Mr Brehm mentions a cock bird that inhabited a wood near Renthendorf, through which there was a roadway, and whenever any one passed through, it would fly towards him, peck at his legs, and strike him with its wings. The black-cock (*T. tetrix*) is a smaller, but very beautiful species, of hardy habits, and much on the increase in many parts of Britain, where it prefers alpine pastures, with a sprinkling of natural wood, intermingled with moist places covered by long coarse herbage. It is widely dispersed over the northern and temperate parts of Europe, and spreads somewhat farther south than the preceding, being found, though rarely, on the Apennines. We know that it breeds among the lofty hills above Albenga, near the Colle de Tende. Other species of bare-toed grouse occur in Europe, and a still greater number in North America. For the history of the latter we must refer to the well-known works of Alexander Wilson, C. L. Bonaparte, Audubon, Richardson, and others.

Of the feather-footed game-birds (genus LAGOPUS), the most noted for gastronomic excellence is our common red grouse, or moor-game (*L. Scoticus*), so highly prized and eagerly pursued by sportsmen. This well-known species restricts itself chiefly to the sides of sloping mountains, and those extensive tracts of elevated land called moors, where it is careless of other shelter than that afforded by the natural roughness of the ground, and its plentiful covering of heath, or other alpine plants of still more lowly growth. The most singular fact in its history is its restriction to Great Britain and Ireland,—all other parts of the world, from "Indus to the pole," being sought in vain for a single example. In this little group we also place the ptarmigans, distinguished from the other grouse by the assumption of a snow-white plumage during winter. These birds seem to prefer, in comparatively temperate climates, such as that of Scotland, the bare and stony sides or summits of the highest mountains; but under the rigorous temperature of Greenland, and the most northern portions of America, they are chiefly found in the vicinity of the sea-shore, by the banks of rivers, and among the willow and other copse woods of the lower and more sheltered vales. The species of Europe and America are not yet in all respects sufficiently characterized and distinguished.

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The genus PTEROCLES, Temm., has a naked space around the eye, but not of a scarlet colour, as in grouse; the toes are bare, the hind one very small, and the tail pointed (Plate XIV., figure 6). These birds, called gangas, or sand-grouse, live in sandy plains and deserts in the warmer regions of Asia and Africa, although two species, *Pt. arenarius* and *setarius*, Temm., inhabit some of the southern countries of Europe, especially Spain. The latter is the pin-tailed grouse of Latham, *Tetrao alchata*, Gmelin.

The genus PERDIX of Brisson contains the partridges, distinguished by having the legs or tarsi bare, as well as the toes. The tail is also very short, although of greater length among the kind called francolins, and other foreign species. Of these several are armed with spurs; and one especially, the sanguine partridge (*P. cruentata*, Temm.), has sometimes three or four spurs on each leg. The francolins perch on trees. The partridges properly so called always rest upon the ground. Their bill is not so strong, and their spurs, if they have any, are very short, or simply tubercular. Four or five sorts are found in Europe, although the common gray partridge (*P. cinerea*) is our only truly indigenous kind. The red-legged partridge (*P. rubra*), which in Italy is the most frequent, has been introduced of late years into the south of England, where it continues to breed spontaneously in a state of nature. Many other species occur in foreign countries.

The quails (genus COTURNIX) are of smaller size than the preceding, the tail is still shorter, the spurs are wanting, and there is no coloured space above the eye. The only British species is the common quail (*C. Europeus*), a well-known bird of passage, generally but not abundantly distributed over the island. In Scotland it is even scarce, although we have found it occasionally near Edinburgh, as well as in Ross-shire, and along the coasts of Aberdeen and Kincardine. The whole migrate from the colder and temperate parts of Europe during autumn, and re-appear in spring, in certain places, in enormous numbers. Along the Neapolitan coasts, for example, 100,000 have been taken in a single day. In some of the southern countries of Europe, however, many quails remain throughout the winter. In Portugal they are even more numerous during that season than in summer; and Signor Savi says, in regard to those of Italy, "Sono le quaglie uccelli viaggiatori, giacchè la massima parte lasciano l'Europa, traversano il mare, e vanno a passare il verno in Affrica, ed in Asia; ma di Toscana, come pure dalle altri parti meridionali, non partono tutti, anzi una gran quantità ne resta per le stoppie delle nostre Maremme, ove trovano e molto nutrimento e dolce clima. Negli ultimi giorni d'Aprile si rimetteno in moto; quelle che avevan passate il mare lo passan di nuovo, e quelle che eransi ritirate ne' siti aprici si spargon per tutti i campi e prati."[2] A vast number of quails of various kinds are found in foreign countries. A beautiful small species (*C. excalfactoria*, Temm.,—*P. Chinensis*, Lath.) is very abundant in China, where it is bred in the domestic state, and kept in cages for the singular purpose of warming people's hands in winter. It is also patronised on account of its pugnacious disposition, being fought with its own kind, as common cocks are in this country.

The American quails now form the genus ORTYX, and are in some measure intermediate between the true quails and partridges. The bill is thick and strong, but short

[1] *Wanderings*, &c. vol. ii. p. 61.

[2] *Ornitologia Toscana*, tom. ii. p. 200.

Rasores. and rounded; the tail more lengthened than in those of the old continent. One species, *O. Californica*, has the head ornamented by a beautiful slender recurved crest. (See Plate XIV., figure 7.) Several other kinds were recently discovered and described by the lamented Douglas, the botanical traveller and collector, whose tragical fate in the Sandwich Islands caused the most sincere regret in the scientific world. They differ from the ordinary quails in usually perching upon trees at night. The Virginian Ortyx, *O. borealis*, has of late been reared in several parts of England, and may be said to be naturalized in Sussex. It is considerably larger than the common quail.

The genus ORTYGIS of Illiger resembles the quails in general form, but the bill is somewhat compressed. The toes are so deeply divided, as scarcely to exhibit a vestige of the usual intervening membrane, and the hind toe is wanting. The species are of small size, and occur in India, Africa, and New Holland. They are of polygamous habits, and dwell in barren places on the confines of deserts, seldom taking wing except when closely run. One of these birds is also much used by the Malays and other eastern nations for fighting with its kind. (See Plate XIV., figure 9.)

A bird of a very anomalous aspect and character, called the heteroclyte grouse (*Tetrao paradoxus* of Pallas), now forms the genus SYRRHAPTES of Illiger. The bill is rather slender and compressed, straight, but as usual somewhat bent towards the tip. The tarsi are short and densely clothed with feathers; the toes are also very short and feathered, and connected together almost to the claws. The hind toe is not wanting, but seems buried in the feathers. The wings and tail are very long, and are both terminated by lengthened slender-pointed plumes. The only known species (named *S. Pallasii* by M. Temminck), inhabits the deserts of Tartary, near the shores of Lake Baikal. Owing to the peculiar structure of its feet, it can scarcely move upon the ground; but its flight is brisk and rapid, though seldom long sustained.

The last group we shall here mention contains the *Tinamous*—genus TINAMUS, Lath.,—*Crypturus*, Illig. (Plate XIV., figure 8.) The bill is lengthened and slender, slightly arched, blunt-pointed, grooved on each side, the nostrils central, deepening obliquely backwards. The wings are short, the tail almost rudimentary. The palmation at the base of the toes is very short; and the hind toe, reduced almost to a little spur, does not reach the ground. The bare space around the eye is very circumscribed. These birds abound in the Brazilian and other tropical forests of America, where they run swiftly, seldom fly, conceal themselves among long herbage, and perch (as some say) upon the lower branches of trees. They live on fruits and insects, and their flesh is much esteemed. Rather than exercise their natural powers of flight, they will sometimes foolishly allow themselves to be killed in great numbers with a stick. They are also hunted with dogs. They build upon the ground, and their eggs are remarkable among those of gallinaceous birds for their brilliant tinting, some being bright blue, others of a brilliant violet colour. The different species of Tinamous exhibit a great diversity in size, from that of a pheasant to a very small quail; and "as for their flesh," says Mr Swainson, "we have often tasted it, and consider it, both in whiteness and flavour, infinitely above that of the partridge or pheasant. We believe these birds never perch, as some suppose, but that they live entirely among herbage, principally in the more open tracts of the interior."[1] Rasores.

The great family of the pigeons (COLUMBA, Linn.) comes next in order in Baron Cuvier's arrangement, and in that indeed of most of our systematic writers. There are several circumstances, however, which make it doubtful whether the pigeons should not form either a separate order of themselves, or undergo some other change in their position. As compared with ordinary gallinaceous birds, every one will admit that they present numerous and striking disparities. Their powers of flight, for example, if equalled are not surpassed even by those of the falcon tribe, their habits are monogamous, their haunts very generally arboreal, their eggs few in number, and hatched by the male as well as female, the young are at first extremely helpless, and are fed for a length of time from the crop of both parents,—in all these points, and many more, they differ remarkably from other gallinaceous birds. Professor Savi, we observe, places the pigeons in his concluding tribe of Passeres (*Uccelli silvani*), as a connecting link with the gallinaceous order, and for reasons closely corresponding with those we have just assigned.[2] Dr Macgillivray was the first to observe that "the beautiful, very extensive, and generally distributed family of birds commonly known by the names of pigeons, doves, and turtle-doves, appears to form an order of itself, separated by well-defined limits; but yet, as in other cases, presenting modifications of form indicative of its affinity to conterminous groups. The peculiar shape of the head and bill, more than any other external feature, serves to render the different species readily cognizable as belonging to a single tribe; for, whatever may be the size, colour, or even shape, of a pigeon, it cannot be mistaken. But the relations of the family, it would appear, are not so readily perceived,—some of our most approved systematists having associated them with the passerine, others with the gallinaceous birds,—while a few consider them as constituting a distinct group. Linnæus included them all under the single genus Columba, which has merely been sectioned by M. Temminck, and from which M. Vieillot has only separated two genera under the names of Treron and Lophyrus; while Mr Swainson and other Ornithologists have converted it into several generic groups, such as Vinago, including the thick-billed species, Ptilonopus, Columba, Turtur, Ectopistes, Peristera, and others, characterized by differences in the wings and tail; and Lophyrus, formed, by Vieillot, of the great crowned-pigeon. The latter seems to connect this family with the Cracinæ, which belong to the gallinaceous order, while other groups manifest an affinity to the partridges and allied genera. The pigeons vary much in form, some having the body full, others slender; while the tail is very short, moderate, or greatly elongated. In all, however, the head is small, oblong, compressed, with the forehead rounded; a circumstance depending partly upon the form of the skull, and partly upon the absence of feathers at the base of the bill. The latter organ is characterized more especially by having the nasal membrane bare, generally scurfy, fleshy, and tumid, with the narrow longitudinal nostrils placed under its anterior margin. It varies in size, but the upper mandible has its ridge always obliterated at the base by the encroachment of the nasal membranes, and its extre- Rasores.

[1] *Nat. Hist. and Class. of Birds*, vol. ii. p. 168.

[2] "Questa tribù forma il passagio dai Silvani ai Gallinacei, giacchè i Piccioni, quantunque somigliano più ai primi che ai secundi, pure han caratteri comuni agli uni ed agli altri. Somigliano i Silvani, perchè avendo ali grandi e coda larga, volano facilmente, con velocità, ed a grandi distanze; sono monogami: nascono nudi, e per un tempo assai lungo (almeno per tutte le specie nostrali) non essendo capaci nè di moversi, nè di cercare il cibo, han bisogno d'esser covati, e imbeccati da' loro genitori: fanno il nido sugli alberi, o nelle buche. Somighano poi i Gallinacei per avere un gozzo molto dilatabile, e dove gli alimenti si trattengono e provano una certa preparazione alla digestione: i semi, di cui quasi esclusivamente si cibano, li inghiottono senza sbucciarli, o romperli, e finalmente, come i Gallinacei, hanno lo sterno doppiamente scavato." (*Ornitologia Toscana*, tom. ii. p. 152.)

Rasores. mity horny, arched, or convex, more or less compressed, with a blunt thin-edged point. The tongue is fleshy, tapering to a point, and triangular in its transverse section. The throat is very narrow. The œsophagus is of moderate width, but expanded, or opening into a large crop, placed on the lower part of the neck and the fore part of the breast, and terminates below in an oblong proventriculus, completely surrounded with large oblong glandules. The stomach is a powerful gizzard of a somewhat rhomboidal form, and furnished with two very thick lateral muscles inserted into two tendinous centres, with an inferior thinner muscle inserted into the same tendons. The intestine is long and slender; the cæca very small and cylindrical; the rectum very short, and but slightly enlarged. The tarsi are generally short and stout, either scutellate or feathered. The foot is of that kind equally adapted for walking and perching, having three toes before and one behind; the middle toe considerably longer than the two lateral, which are nearly equal, and the hind toe directed backwards, and shorter than the lateral. They are covered above with numerous short scutella, laterally margined, beneath flat and papillate. The claws are short, compressed, moderately arched, rather blunt. The plumage is various, so that no general character can be derived from it, farther than that the feathers have the tube very short, the shaft commonly thick, and are entirely destitute of the accessory plumule, which is largely developed in the gallinaceous birds. The wings are for the most part large, more or less pointed, with the second, third, and fourth quills longest; but the primary quills vary in form, and present several very curious modifications. The tail is even, rounded, cuneate, or graduated."[1] The skeleton, Dr Macgillivray further remarks, differs very materially from that of gallinaceous birds, and the intestine is much longer, the difference, however, in the other Gallinæ being made up by the great development of the cæca, which in pigeons are merely rudimentary, that is, extremely small, and secreting only a mucous fluid. We may add the following important character, that the hind toe is articulated on the same plane with the three anterior ones, instead of being placed higher up, as in the rest of the gallinaceous order. Although their legs are short, pigeons walk with great ease and considerable celerity.

These beautiful birds abound in most of the temperate and tropical regions of the earth, being, however, both more numerous and more gorgeously attired in the latter, where they often rival even the tribe of parrots in the splendour of their plumage, and literally realize the delightful expressions of the Holy Scripture—"as the wings of a dove covered with silver, and her feathers with yellow gold." The old genus Columba is one of the most cosmopolite with which we are acquainted, being found diffused alike through Europe, Asia, Africa, and America; and even in the forests of the far-distant Southern Ocean, their radiant plumage

> Fills many a dark obscure recess
> With lustre of a saintly show.

In no tribe of the feathered race do we meet with more to delight the eye by its richness and diversity. "In some," says Mr Selby, "the plumage shines with a dazzling and metallic gloss, varying in tint with every motion of the bird, and which vies in lustre with that of the diminutive and sparkling humming-birds. In texture the plumage is generally close and adpressed, and the feathers feel hard and firm to the touch, from the thickness and strength of the rachis or shaft. Upon the neck they assume a variety of forms, in some species being rounded and stiff, and disposed in a scale-like fashion; in others of an open, disunited texture, or with the tips divided and curiously notched; and in the hackled and Nicobar pigeons they are long, acuminate, and laciniated, like those of the domestic cock; and, we may add, that in nearly all they are so constituted as to reflect prismatic colours when held at various angles to the light."[2] Rasores.

The vast variety of species and numerous sub-genera of which the *Columbidæ* are now composed render a full exposition impossible. We must, indeed, rest satisfied with a very brief notice of a few remarkable kinds. We have four species of pigeon in Britain, and we are not aware that more occur in Europe.

1*st*, The ring-dove, cushat, or wood-pigeon, *C. palumbus*, Linn., a large, beautiful, and well-known species, very generally distributed over the more or less wooded districts of our island, but avoiding bare and rocky regions. It breeds on trees in single isolated pairs, but is often gregarious to a great extent in winter. It is a wary bird, of powerful wing, not easily approached even in the forest glades, yet not seldom building in groves or groups of trees in the immediate vicinity of human dwellings; and we have seen a gentle pair sitting for hours upon the branches of an almost leafless sycamore in early spring, preening their feathers in assured confidence, within a few footsteps of our cottage door. Indeed we have often noticed, as others must have also done, what may be called the *discrimination* of birds, in relation both to persons and to places. We allude to what we should call their accommodating rather than their natural instincts,—how, for example, after a season or two of observation or experience, they will congregate around a spot where no rude hands disturb their mossy dwellings, nor climbing urchin shows his visage grim among the umbrageous boughs. This is beautifully exemplified (and on a greater scale than in a cottage garden) among the gladsome palace-groves of the Tuileries and Luxembourg in Paris, where, notwithstanding the gay and giddy stream of human life which flows for ever through those royal walks, the wood-pigeon builds her frequent nest, though far her flight to rural solitudes for every offering which she brings her much-loved young. This species generally breeds twice a year.

2*dly*, The rock or wild pigeon, *C. livia*, Briss., a smaller species, totally regardless of all the leafy glories of the forest, but loving devotedly the craggy cliffs and hollow caverns by the ocean-shore. This species is believed to be the original of our common domestic breed, of which the numerous and extraordinary, yet, with proper care, permanent varieties, are among the more puzzling problems of Ornithology.[3]

3*d*, The smaller wood-pigeon, erroneously called the stock-dove, *C. œnas*, Linn. This bird is much more limited in its distribution than either of the preceding, being as yet unknown in Scotland, and frequenting chiefly the southern and midland counties of the sister kingdom. It is almost entirely confined to wooded districts, its habits, according to Mr Selby, being strictly arboreal; yet Mr Salmon records it as abounding in heaths and rabbit warrens in the neighbourhood of Thetford, to which it annually resorts for the purpose of nidification.[4]

4*th*, The turtle-dove, *C. turtur*, Linn., a small and delicate species, unknown in "bleak Caledonia," but a constant summer bird in Kent, and other counties of the south of

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[1] *British Birds*, vol. i. p. 249.

[2] *Naturalist's Library*, vol. v. p. 88.

[3] For the domestic breeds, see Temminck's *Hist. Nat. Gén. des Pigeons et des Gallinacées*, MM. Boitard and Corbie's *Monographies des Pigeons Domestiques*, the *Pigeon Fancier*, and other works.

[4] *Magazine of Natural History*, vol. ix. p. 520.

Rasores. England, where it breeds in woods. It is sometimes seen towards the end of summer in little flocks of a score or two together. This bird leaves Britain in the course of the autumn, and does not to our knowledge remain in any part of Europe throughout the winter season.

Of the exotic pigeons one of the most remarkable is the goura, or great-crowned pigeon, *Lophyrus coronatus*, Vieillot. (See Plate XV., figure 1.) It is by far the largest of the tribe, measuring nearly two feet and a half in length. It inhabits Java, New Guinea, and most of the Molucca Islands, and is occasionally brought alive to Europe, where, however, the climate is too moist and variable to admit of its ever attaining to a good old age.

One of the most magnificent of the tribe is the hackled pigeon (*C. Franciæ*), distinguished by the irregular form of the feathers on the head, neck, and breast, which are long and narrow, and terminate in a shining appendage resembling in consistence, though not in colour, the tips of the wing-feathers of the waxen chatterer. It inhabits Southern Africa and the island of Madagascar. Another singular species is the parabolic pigeon (*C. arquatrix*), discovered by Vaillant, and figured in his splendid work on the birds of Africa. The flight of this bird is very remarkable. It never proceeds in a straight line, but on commencing its route describes a parabola, and continues forming a series of arcs during the whole time, frequently uttering a peculiar cry. It inhabits the forests of Anteniquois, and is so bold as to persecute the white eagle.

The carunculated pigeon (*C. caruneulata*, Temm.) is placed by Mr Selby with the ground doves, genus GEOPHILUS of that author. This little group is not only distinguished by a greater length of tarsus and other organic characters, but by a striking departure from the general economy of the Columbidæ, the number of eggs not being confined to two, but extending to eight or ten. Incubation also takes place upon the ground; and the young, like those of the true gallinaceous birds, are produced from the egg in so matured a state as to follow their parents from the first. They live entirely on the ground, but roost at night on trees and bushes. The carunculated species just referred to is observed by M. Temminck to show a strong resemblance to the gallinaceous tribes both in aspect and manners. The fleshy scarlet lobes around the eyes and throat correspond, it is supposed, to the wattles of domestic poultry. It builds its nest in slight depressions on the ground, of twigs and stems of grass, and lays from six to eight eggs, which are sat upon alternately by male and female. The young are able to follow their parents as soon as hatched, and are led about by them, and brooded over with extended wings. Their first food consists chiefly of the larvæ of ants and other insects, and when greater strength is gained, of seeds and berries. The beautiful Nicobar pigeon (*C. Nicobarica*, Lath.) has been likewise referred to the same genus. Though of a heavy form and ungraceful carriage, it yields to none of its tribe in splendour of plumage, of which the prevailing hue is rich metallic green, with various reflections of copper and purplish red. It is generally described as residing habitually upon the ground, where it runs with great celerity,—perching on the lower limbs of trees at night. Yet Mr Bennet alludes to this species as usually seen perched on trees, even on the loftiest branches,—where, he adds, it rears its young "similar to all the pigeon tribe."[1] It inhabits Nicobar, Java, Sumatra, and other eastern islands.

We have already alluded briefly to the turtle-dove. The most common kind in cages, in this country, is not the English species, but that called the laughing or collared turtle, *T. risorius* (*torquatus*, Briss.). It is bred with great facility in Britain, but the winter cold would probably be too much for it out of doors; and it seems, moreover, to want that instinct of local attachment which induces our common pigeon to continue in the place where it was born and bred. In its natural state this species occurs in various parts of Africa. Gralla-tores.

Somewhat resembling the turtles in the length of its wings and tail is the famous passenger pigeon of America, of whose rapid flight and countless congregations we have such graphic accounts in the delightful pages of Wilson and Audubon. This bird is the *Columba migratoria* of authors, and is placed by Mr Swainson in his genus ECTOPISTES. It may be presumed to be sufficiently common in North America, from a fact, or rather calculation, given by Alexander Wilson. He estimated a flock which continued to pass above him for the greater part of a day, to have been a mile in breadth, and 240 miles in length, and to have contained (three birds being assigned to every square yard), at least *two thousand two hundred and thirty million two hundred and seventy-two thousand pigeons!* Mr Audubon confirms his predecessor's account by a narrative still more extraordinary; and adds, that as every pigeon consumes fully half a pint of food (chiefly mast), the quantity necessary for supplying *his* flock must have amounted to *eight millions seven hundred and twelve thousand* bushels per day![2] We wonder, after this, that any farmer should ever dare to migrate to America.

The genus VINAGO of Cuvier consists of pigeons with strong solid compressed bills, short tarsi, and broad distinctly bordered feet. They inhabit forests, live on fruits and berries, and occur in the tropical regions of the old world. Their prevailing colours are various shades of green and yellow, contrasted with purple or reddish brown. The *Columba aromatica* of Latham is a Vinago. (See Plate XV., figure 3.)

We shall now close our brief sketch of the gallinaceous order.

ORDER V.—GRALLATORES.[3]

SHORE-BIRDS, OR WADERS.

The characters of this order, so far as they can be formally stated, are as follows. The shape of the bill is indeterminate. The legs are long and slender, and more or less bare above the tarsus. There are three anterior toes, more or less united at their bases by a membrane or rudimentary web. The hind toe is wanting in one division of the order.

Among the extensive and varied tribes which constitute the grallatorial order, the bill, as we have just intimated, is formed after so many different models (though always in beautiful accordance with the habits of each particular group), that its structure cannot be generalised, or sententiously expressed. The structure of the feet and legs is also admirably adapted for the exercise of their peculiar habits of life, being so lengthened as to admit of the species wading to a considerable depth without wetting their feathers, and of running with great rapidity along the margins of lakes and rivers, or the sea's more sandy shores. It is to this length of limb that they owe the name of *Grallatores*, as if they went on stilts. The French title of *echassiers* is also derived from the resemblance which the legs bear to the *echasses*, so frequently used by the natives of the *landes* of Aquitaine. A too exclusive attention, however, to this character seems to have misled some modern naturalists, who have included several very remotely

[1] *Wanderings*, &c. vol. ii. p. 64.

[2] See his interesting account of the passenger-pigeon, in *Ornithological Biography*, vol. i. p. 319–26.

[3] GRALLÆ, Linn.

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allied genera under one order. Indeed a considerable diversity of opinion exists as to what ought to form the component parts of the grallatorial order. By means of the flamingoes and others, they are closely allied to the natatorial or web-footed birds,—while a dismemberment, partly from the latter order, partly from the original Grallæ, has been advocated in favour of the Grebes, Phalaropes, &c. as a separate and intermediate division under the name of *Pinnatipedes*.

The Grallatores seek their food in marshes, and along the banks of rivers and the shores of lakes. They also frequent the sea-coasts, where many kinds, especially in autumn, congregate in numerous flocks. But although the habits of the majority are *littoral*, many haunt habitually the arid deserts, the green and sedgy meadows, or the upland moors. Who knows not the plover's wailing cry among the desolate mountains,—the curlew's shrilly voice, "a viewless spirit of the elements," far up amid those scenes of pastoral melancholy, where the lonely rocks seem sometimes silent as gigantic spectres, and anon resound with varied and innumerable bleatings, as some gray-haired shepherd, "loving the land which once he gloried in," his dog his sole companion, gently leads along the fleecy people? In truth we often seek in vain to generalise the habits of the feathered race. In our systems we can give them both a local habitation and a name, but in nature they have wings, and like the wind travel where'er they please, and no philosopher either from field or college can say from whence they come, or whither they are going. The food of our present order varies according to the form of the mandibles. Such species as are provided with a long, hard, sharp-pointed bill, as in the heron tribe, live on fish and reptiles; the species in which that organ is softer and more flexible feed on worms and insects, whilst a more limited number, for example the land-rail (*Rallus crex*). are partly granivorous, and consequently affect a drier soil. The jacana (*P. chavaria*) is said to feed on grass. The habits of many species are migratory; and it has been remarked, that the young and old birds always perform their journeys in separate assemblages. A great proportion of the order congregates in the southern countries of Europe before the arrival of winter,—a season which many of them are supposed to spend in Africa. A few are winter birds of passage, that is to say, the temperate countries of Europe form their southern boundary, and during the breeding season they seek the colder regions of the north. The woodcock breeds in Scandinavia, where the observant traveller may frequently see it, not as with us the harbinger of storms, but darting across his dappled dusty path "in the leafy month of June." However, in several parts of the north of Scotland, woodcocks are now very frequent throughout the summer season, rearing their absurd-looking, long-billed progeny along the banks of the Dee, or in the well-wooded valleys of the eastern parts of Ross-shire. The smaller species, such as rails and sandpipers, run with great celerity; the paces of the larger kinds are more measured and sedate. During flight the legs in many kinds are extended on a line with the body. In some entire genera, and in certain species of other genera, the moult is double, that is, takes place both in spring and autumn, and occasions a great disparity between the plumage of the winter and summer seasons. The attire of the sexes is for the most part not very dissimilar. An apparent non-conformity may be said to exist in a few of the species, between the structure of the feet and the functions of these organs, which would disenable us from indicating, *a priori*, the habits of such species merely from an inspection of their organization. For example, the waterhen (*Fulica chloropus*) is an excellent and constant swimmer, and much more strictly aquatic than the avocet or flamingo, yet its toes are long and deeply divided, and furnished with an extremely narrow rudimentary web, while the last-named species, though semi-palmated, never voluntarily venture beyond their depth.

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The migratory movements of the Grallatores are probably determined in a great measure by the necessity of obtaining suitable nourishment. The rigour of a Scandinavian winter, which entirely congeals the surface of the moist forest-lands of Sweden and the swamps of Lapland, drives the woodcock to seek its food in the comparatively milder copses of Britain and Ireland; while the landrail, which is with us a native or summer bird, migrates in autumn to more southern regions, where it is probably known only as a winter visitant. Analogous facts have been observed in various parts of the world. Thus in regard to North America, the Grallatores, feeding by preference in marshy and undrained lands, frequent the Saskatchewan prairies only in the spring; and as soon as the warm and comparatively early summer has rendered the soil too dry for their accustomed purposes, they retire to their breeding places within the arctic circle. "There," says Dr Richardson, "the frozen sub-soil, acted upon by the rays of a sun constantly above the horizon, keeps the surface wet and spongy during the two short summer months, which suffice these birds for rearing their young. This office performed, they depart to the southward, and halt in the autumn on the flat shores of Hudson's Bay, which, owing to the accumulations of ice drifted into the bay from the northward, are kept in a low temperature all the summer, and are not thawed to the same extent with the more interior arctic lands before the beginning of autumn. They quit their haunts on the setting in of the September frosts, and passing along the coasts of the United States, retire within the tropics in the winter."[1]

The majority of the Grallatores are swift and powerful flyers, being provided with rather long, acutely-pointed wings; but to these attributes we have a few strong and singular exceptions in such birds as the ostriches and cassuaries, which have scarcely any wings, and cannot fly at all.

Baron Cuvier has established the five following tribes among the Grallatores, viz. Brevipennes, Pressirostres, Cultrirostres, Longirostres, Macrodactyles.

Tribe 1st.—Brevipennes.

The small number of gigantic birds which constitute our present tribe differ greatly, not only from the other Grallæ, but from all known species; 1*st*, in the extreme shortness of their wings, which, though no doubt useful in their way, are altogether destitute of power to raise their bodies from the earth; and, 2*dly*, in the sternum or breast-bone being destitute of a ridge or keel. The muscles of the breast are also extremely slight and thin. "Il parait," says Cuvier, "que les forces musculaires, dont la nature dispose, auraient été insuffisantes pour mouvoir des ailes aussi étendues que la masse de ces oiseaux les aurait exigées pour se soutenir en l'air."[2] This is not expressed according to the English mode of thought and feeling, but it may pass for what it means. To make amends, however, for this supposed incapacity of nature, we find that the muscles of the legs have received an enormous development, which enables the species to run almost with the rapidity of race-horses, and to be thus independent of aërial flight. In some of our modern systems these birds form the family *Struthionidæ*, and are placed in the gallinaceous order.

In the genus Struthio, which contains the true ostrich,

[1] *Fauna Boreali-Americana*, part ii. Introduc. p. xix.

[2] *Règne Animal*, tom. i. p. 494.

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the wings are adorned by loose flexible plumes, and though of small extent, are still sufficient to afford effectual aid in running. The toes, at least externally, are only two in number.

The only known species is the ostrich commonly so called (*Struthio camelus*, Linn., Plate XV., figure 5), a bird which forms one of the most remarkable characters in the Ornithology of Africa, to which country it is believed to be almost entirely peculiar. It presents the tallest, and in many other respects the most singular example of the feathered race. It measures from six to seven feet in height; its head is very flat, extremely small, and almost naked; as is also the upper portion of the neck, which is very slender, and nearly three feet long. The general plumage of the male is black, varied with white and gray, the fine full feathers of the wings and tail being either black or white. Our engraving will best explain its outer aspect. The female is brown or ashy-gray upon the body; the young are likewise of the latter hue, and have at first the head and neck densely clothed. The ostrich inhabits the deserts of Arabia, and a vast extent of open sandy plains in Africa, from Barbary to the Cape of Good Hope. Being consequently native to one of the most anciently peopled countries of the earth, it has excited the attention of mankind from the remotest periods of antiquity. It is frequently mentioned in the book of Job, and in other portions of the Old Testament. Herodotus among the early Greek writers was well acquainted with its history and appearance, and in after times it was not only frequently exhibited by the Romans in their games, but the brains of hundreds at a time were scooped out as a choice delicacy for the luxurious table of Heliogabalus.

The ostrich is gregarious and polygamous. The female deposits her eggs, weighing nearly three pounds, in the sand. These, in equatorial regions, are hatched by the heat of the sun, with little or no attention on the part of the mother; but on either side of the tropics are said to be incubated in the usual fashion. This gigantic bird feeds naturally on seeds and herbage; but its taste is so obtuse, and its swallowing propensities so universal, that there are few substances, however incongruous or indigestible, which it declines. It is said by some to be the swiftest of all running creatures, and Adanson seemed satisfied that those he saw at Podor, a French factory on the southern side of the Niger, would have distanced the fleetest race-horse that was ever bred in England. There is no doubt that the peculiar construction of birds, in relation both to the respiratory and circulating systems, is such as to admit of their keeping in much better *wind* than is possible for any quadruped; and when, as in the case of the species in question, great muscular power is superadded, the natural result must be prodigious swiftness.

The nandou or American ostrich now forms the genus Rhea, of which it is the sole species, characterized by having three toes, the wings terminated by a little spur, and the tail wanting. It is not above half the size of an ostrich, of a whitish-gray, lead coloured on the back, the head covered with close-set blackish feathers, almost as stiff as hair. This bird inhabits the pampas of Paraguay, in troops of a few dozen, and extends almost as far south as the Straits of Magellan. It is a gentle, innocent creature, of herbivorous habits, easily tamed if taken young, and laying an enormous number of eggs. As several females sometimes sit together, it is probable that the number of seventy or eighty eggs, alleged to have been found in a single nest, are not the produce of one bird, but rather the result of a kind of joint-stock incubating company. Its flesh is eaten by the Indians, and its feathers, from their peculiar structure, make very good hair-brooms.

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In the genus Casuarius, the wings are still shorter than in either of the preceding, and seem of no use even in running. They consist, in fact, merely of a few hard, stiff, sharp-pointed, barbless shafts. The head is surmounted by a bony crest, and the bill is laterally compressed (see Plate XV., figure 2) The sole species is the common cassuary (*C. galeatus*, Vieil.), a bird first imported to Europe by the Dutch in 1597. Like the rest of its tribe, it is extremely large, measuring about five feet in height. Its plumage is very peculiar, being long, narrow, decomposed. and hair-like, and the *plumule*, or short inner feather (which exists in almost all birds except pigeons), is of nearly equal length with the outer portion, so that an appearance is produced of there being a double feather to each quill. The prevailing colour is blackish. The cassuary inhabits the Moluccas, Ceram, Bourou, and especially New Guinea. These birds usually live in pairs, and the female lays three eggs, of a greenish hue, and punctured surface. They run with great swiftness, and defend themselves from dogs and other animals, by kicking like horses. The inner claw is very large and strong.

The emeu, or New Holland cassuary, forms the genus Dromecius of Vieillot. The bill is much depressed, the head feathered, without osseous crest, the throat naked. The claws are of nearly equal length. The general colour is dull brown mottled with dingy gray; the young are striped with black. The plumule is equally extended as in the preceding species. (See Plate XV., figure 6.) Next to the ostrich, the emeu is the tallest bird we know. Its flesh affords admirable eating,—"truly exquisite," says Peron, "and intermediate, as it were, between that of a turkey and a sucking pig." Mr Cunningham compares it to beef, which is also an excellent thing. This bird is widely spread over the southern parts of New Holland and the adjacent islands. It is tamed with great ease, and of late years has frequently bred in Britain.

In the genus Apteryx of Shaw,[1] the bill is slender and of considerable length, the legs short, with three anterior toes, and a posterior spur to represent the hallux. The wings are rudimentary. The only known species was obtained a number of years ago on the south coast of New Zealand, by Captain Barclay of the ship Providence, and was presented by him to Dr Shaw. It equals a goose in size. This bird, of which the history was long obscure, was several years ago received in London.[2]

The last ornithological form to which we shall allude under our present tribe is the mysterious Dodo (*Didus ineptus*), a bird which some regard as an extinct, others as a fabulous, species. In neither supposition would it fall within the limits of our present treatise, which seeks to present a sketch, however imperfect, of living nature; and we shall therefore not occupy our narrow limits by a subject of "doubtful disputation," on which we cannot ourselves throw any light, having neither been in the Mauritius, nor studied the works of Clusius and the early Dutch navigators.[3]

Tribe 2d.—Pressirostres.

This tribe consists of the bustards, plovers, and other species which, like all the preceding, either want the hind toe, or have it so short as not to touch the ground. The bill is of medium size, but of sufficient strength to pierce the ground in search of worms and insects, the feebler

[1] *Naturalist's Miscellany*, pl. 1057–8.

[2] Yarrell, in *Zool. Trans.* i. pl. 10.

[3] Whoever desires it, will find a summary view of authorities regarding the dodo, by Mr T. S. Duncan, in the *Zoological Journal*, No. xii. p. 554

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species often frequenting moist meadows and tilled ground in search of food. The stronger billed kinds feed also on grain, &c.

The genus Otis, Linn., possesses the bulky massive form of the gallinaceous order, and the upper mandible is somewhat arched; but the bare space above the tarsus, the want of the hind toe, and the general structure both outward and internal, connect them more closely with the Grallatores. The great bustard (*Otis tarda*) is the largest of the European birds, and one of the rarest of our British species. It sometimes weighs nearly thirty pounds, and is now believed to be confined exclusively to Norfolk. We have another species called the little bustard (*O. tetrax*), also very rare. Many fine species occur in Africa and the East. (See Plate XV., figure 4.)

The genus Charadrius, Linn., likewise wants the hind toe. The bill is compressed, and somewhat enlarged towards the tip. It contains the various species commonly called plovers, and may be divided into two. 1*st*, Œdicnemus, Temm., in which there is an inflation towards the terminal portion of the bill in both mandibles, and the nasal fossæ are less prolonged. These are the larger species, of which the great plover (*Œdic. crepitans*), or thick-knee'd bustard of our English writers, affords a good example. It is a migratory bird, of rare occurrence, confined chiefly to our southern and eastern counties, which it visits about the end of April. It is as yet unknown in Scotland. This bird is a nocturnal feeder, and preys principally upon insects. 2*d*, Charadrius, in which the bill is inflated only above, and two thirds of its length on each side are occupied by the nasal fossæ, which renders the organ comparatively feeble. The species are gregarious, and, like the gulls, beat the moist soil with their pattering feet, to terrify the incumbent worms. "The members of this genus," says Mr Selby, "are numerous, and possess a very wide geographical distribution, species being found in every quarter of the globe. Some of them, during the greater part of the year, are the inhabitants of open districts and of wild wastes, frequenting both dry and moist situations, and only retire towards the coast during the severity of winter. Others are constantly resident upon the banks or about the mouths of rivers, particularly where the shore consists of small gravel or shingle; such are most of the smaller species. Except during the season of reproduction, most of them live in societies, larger or of less amount, according to the species. Their migrations are also performed in numerous bodies, the old birds usually congregating by themselves, and preceding the young in their periodical flights. They run with much swiftness, as might be expected from the simple structure of their feet; and from the shape and dimensions of their wings, they fly with strength and rapidity. They live on worms, insects, and their larvæ, &c. and most of them are nocturnal feeders, as indicated by their large and prominent eyes. They are subject to the double moult, and the change at the different seasons is in many species very marked. Their nest is on the ground, and their eggs are always four in number. The flesh of the larger species, and such as inhabit the plains of the interior, is delicate and high flavoured; but in many of the smaller kinds, that live on the coast, or on the banks of rivers, it is not so palatable."[1] The beautiful golden plover (*Char. pluvialis*) is the best-known example to which we need refer. The prevailing plumage of the upper parts is brownish, or very deep hair-brown, each feather being tipped and otherwise spotted with yellow. The chin and throat are white, the fore part of the neck, breast, &c. ash-gray, streaked with darker gray, and tinged with yellow. During the breeding season, the cheeks, chin, throat, fore part of the neck, centre of the breast, and abdomen, are of an intense black, and in this state it has been erroneously regarded as a distinct species. To the same group belong the dotterel (*Char. morinellus*), the ring-plover (*Char. hiaticula*), and many other kinds, exotic and indigenous. Several of the foreign plovers have sharp spurs upon the anterior margin of the wing, as well as fleshy flattened lobes upon the head.

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The genus Vanellus of Bechstein differs but little from the plovers, except in the possession of a small hind toe. We here place our elegant crested lapwing, or green plover (*V. cristatus*), commonly called in Scotland the *pees-weep*. The gray plover (*C. squatarola*, Linn.) forms the genus Squatarola of Cuvier, distinguished, like the preceding, by a very small hind toe; but the bill is more bulged beneath towards the extremity, and the nasal fossæ are short.

The genus Hæmatopus, Linn., commonly known by the name of oyster-catcher, has the bill rather long, straight, pointed, compressed. The hind toe is wanting. Our British species (*H. ostralegus*), breeds along the rocky ledges of friths and bays, and is said to open oyster and other shells by means of its bill. We could never detect it in the performance of this feat, and we rather doubt the fact, till assured of it by a credible eye-witness. Oysters are by no means easily opened, even with a knife. Several nearly allied species have been discovered of late years in Asia, Africa, and America. One is found in New Holland.

In the genus Cursorius the bill is slender, rounded, somewhat arched, without furrow. The legs are long, the hind toe wanting. Five or six species occur in Africa and Asia, and of these, *C. Isabellinus*, Meyer, sometimes accidentally appears in the south of Europe. A few specimens have been even seen in Britain.

The genus Microdactylus, Geoffroy (*Dichlophus*, Illiger), has the bill stronger and more curved, with a wider gape. The legs are of great length, the toes slightly palmated at the base, the hinder one very small, and not reaching to the ground. The only known species is a singular South American bird called the *çariama* or crested screamer (*M. cristatus*, Geoff.,—*Palamedea cristata*, Gm.). It is larger than a heron, the plumage reddish gray waved with brown, the forehead ornamented by a crest of recurved slender feathers. (See Plate XV., figure 3.) The plumes of the head and neck are also decomposed. The çariama inhabits elevated plains in Brazil and Paraguay, where it feeds on serpents and other reptiles, as well as on insects and their larvæ. It flies feebly, owing to the shortness of its wings, but runs with considerable swiftness. When pursued, it is apt to conceal itself by squatting in some cunning corner. Its flesh affords excellent food, and it is sometimes reared by the Spaniards in a domestic state. The female lays only two eggs.

Tribe 3d.—Cultrirostres.

In this tribe the bill is usually strong, of considerable length, straight, cutting, sharp-pointed. In many species the trachea undergoes a peculiar duplication in the male sex. The cæca are short. Cuvier divides the tribe into three lesser groups,—the *cranes*, the *herons*, and the *storks*.

The cranes properly so called (genus Grus) have the bill longer than the head. The most noted species is the common crane of Europe (*G. cinerea*), a migratory bird,

[1] *British Ornithology*, vol. ii. p. 230.

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well known in Britain during former ages, and still breeding in the northern and eastern countries of Europe.

> Part loosely wing the region, part more wise,
> In common, ranged in figure, wing their way,
> Intelligent of seasons, and set forth
> Their airy caravan high over seas
> Flying, and over lands with mutual wing,
> Easing their flight; so steers the prudent crane
> Her annual voyage, borne on winds, the air
> Flotes as they pass, fann'd with unnumber'd plumes.

In our own island the appearance of this bird now-a-days may be regarded as accidental. It is a very large species, measuring above four feet in height. The prevailing plumage is of a deep ash-gray, the face and throat black, the rump and tertial feathers very long, loose, flowing, decomposed.

The whooping crane of the new world (*Grus Americana*) has a pure white plumage, with black primaries. (See Plate XVI., figure 1.) This stately bird, when standing erect, measures nearly five feet in height, and is the largest of the feathered inhabitants of the United States (bating Lynch law and the use of tar). It is widely spread over North America, from which it usually retires in winter to the West Indies, although a few hybernate in the warmer parts of the Union, or even linger throughout that inclement season in the swamps of New Jersey, near Cape May. When wounded this crane defends itself with vigour, and has been known to strike its bill through a person's hand with the strength and sharpness of a dagger. It builds upon the ground, and sometimes congregates in vast flocks, the clamour of which is more easily imagined than described. It was heard with astonishment by Captain Amidas, the first Englishman who ever landed in North America, when he visited the island of Wokokou, off the coast of North Carolina. "Such a flock of cranes," says he, "(the most part white) arose under us, with such a cry, redoubled by many echoes, as if an army of men had shouted all together." The bustle of their great migrations, and their passage, as of mighty armies, fill the mind with wonder. Mr Nuttall, while descending the Mississippi in December, observed the whooping cranes in countless thousands, as if assembled from all the swamps and marshes of the north and west,—as if the entire continent was giving up its quota to swell the mighty host. Their flight took place during the night, down the great aërial valley of the river, whose southern course conducted them every instant towards more genial climes. "The clangour of these numerous legions passing along, high in the air, seemed almost deafening; the confused cry of the vast army continued with the lengthened procession, and as the vocal call continued nearly throughout the whole night without intermission, some idea may be formed of the immensity of the numbers now assembled on their annual journey to the regions of the south." Several other fine cranes inhabit America, as well as Africa, and the East.

The beautiful Balearic crane (*A. pavonina*, Linn.) belongs to the genus Anthropoides of Vieillot. (Plate XV., figure 9.) It occurs in Africa and in some of the Mediterranean islands. The *Demoiselle* (*A. virgo*), remarkable for its peculiar and what may be almost called *affected* gestures, is nearly allied. It is likewise of African origin, as is also the Stanley crane (*Anth. Stanleyanus*), belonging to the same restricted group, and more recently described by Mr Vigors.[1]

In the genus Psophia, which contains the South American trumpeters, so called from their peculiar voices, the bill is less elongated, and the head and neck clothed with short down-like feathers. *P. crepitans* is easily domesticated, and becomes much attached both to places and to persons. It is even said to act as a guard or conductor to domestic poultry. It flies indifferently, but runs with great swiftness. (Plate XV., figure 7.) There are only two species.

The genus Aramus of Vieillot is constituted by the *courliri* of Buffon, or scolopaceous heron, of which the bill, slenderer and more deeply cleft, is inflated towards the tip. The toes, all rather long, have no palmation. The only known species (*Ar. scolopaceus*) inhabits Cayenne, Brazil, and Paraguay, spreading into Florida and other southern parts of the Union. It is a shy and solitary bird, dwelling in pairs, and crying in a loud sonorous voice, continually by night and day, *carau, carau*. It runs swiftly, and builds upon the ground, but often lights on trees. It is not fond of wading.

A still more singular bird, classed by Linnæus with the herons (*Ardea helias*), is the caurale snipe of Latham, which now forms the genus Eurypyga of Illiger. "C'est un oiseau," says Cuvier, "de la taille d'un perdrix, à qui son cou long et menu, sa queue large et étalée, et ses jambes peu élevées, donnent un air tout différent de celui des autres oiseaux de rivage. Son plumage, nuancé par bandes et par lignes, de brun, de fauve, de roux, de gris, et de noir, rappelle les plus beaux papillons de nuit. On le trouve le long des rivières de la Guiane."[2]

The second group of the cultrirostral tribe, composed chiefly of the herons, is more strictly carnivorous than the preceding.

The first genus is Cancroma, Linn., composed likewise of a single species called the boat-bill—*C. cochlearia*. The bill is comparatively short, but very broad, boat-shaped, with the upper mandible overlapping the lower. It inhabits the moist hot regions of South America, frequenting the banks of rivers, preying on fish, and building its nest on low bushes. It is of an irritable passionate nature, and when enraged raises the feathers of its crest, so as to alter its usual aspect surprisingly. As it scarcely ever frequents the sea-coast, its alleged propensity to feed on crabs is probably ill founded. The boat-bill varies considerably in plumage, but it does not appear that there is more than one authentic species.

The genus Ardea, Cuv., contains the true herons. The bill is as long or longer than the head, strong, hard, straight, compressed, sharp-pointed; the masticating edges sharp, the culmen rounded. The eyes are encircled by a bare skin, which extends to the base of the bill. The herons form a considerable group, almost all of which, according at least to our particular taste, are remarkable for beauty of plumage. They seldom, however, exhibit a preponderance of the brighter or more gaudy colours, such as red or yellow, being chiefly distinguished by a delicate harmonious blending of pearly-gray and brown, black, white, pale blue, slate-colour, and other sober hues. The *forms* of the plumage are graceful and elegant. Long pendent plumes frequently ornament the hinder portions of the head and neck, the lower part of the breast, and the dorsal region. The body is usually small and light, the limbs long and delicate, the toes narrow and taper, and the neck thin, pliant, and extremely graceful. Many species formerly regarded as true herons are now excluded from the modern genus. The habits of the heron tribe are fully as aquatic as those of the majority of Grallatores. They usually walk, or rather wade, along the shores of lakes, rivers, stagnant marshes, or the land-locked waters of narrow seas, in search of their natural food, which consists of fish, frogs, several marine and fresh-water shells, slugs, worms, and various insects. During flight they extend their legs backwards instinctively, as if to counterbalance the weight of the anterior extremity, and by a duplication of the neck they lower the head between the shoulders. In some instances

[1] *Zool. Journal*, vol. ii. p. 234, pl. viii.

[2] *Règne Animal*, tom. i. p. 509.

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they are gregarious, in others solitary. In the former case they build in trees,—in the latter, more frequently among reeds or rushes. Several species afford an excellent though now much-neglected article of food, and were not only prized as such in England in the olden time, but were objects of still higher interest and regard, as affording the finest display of strength and intrepidity in the practice of the noble art of falconry. Birds of this genus occur in almost every quarter of the known world. The species which inhabit high northern latitudes, such as Kamtschatka and the shores of Hudson's Bay, migrate southwards before the arrival of winter. Such as breed in warm or temperate climates are more stationary.

Our common or long-necked heron (*Ardea major et cinerea*, Linn.) affords a familiar example of the genus. "Yon Cassius hath a lean and hungry look," yet when examined close at hand he is an elegant and beautifully plumaged species. The heron usually builds on the tops of lofty and umbrageous trees, yet in an island of Loch Conn we have seen its nest on *pollards* not more than ten feet high; and we lately noticed a large heronry among the precipitous cliffs which overhang the sea about a mile outside the entrance to the Cromarty Frith, upon the northern shore. We have several other British herons, the majority of which, however, must be regarded rather as stragglers or accidental visitors, than as truly indigenous species. The egrets are beautiful crested herons, with the plumage usually pure white, and in part decomposed, or very loose and flowing. Of these, the little egret (*Ardea garzetta*, Linn.) is common in Turkey, and the east of Europe, as well as in many parts of Asia, Africa, and the islands of the Mediterranean. It is frequently alluded to in the ancient household books of England; and in the recorded bill of fare of the famous feast of Archbishop Neville, in the reign of Henry IV., a thousand are said to have been served up at a single entertainment. It is indeed extraordinary that a bird now so rare in all the western countries of Europe, should have been at any time so superabundant in Britain; and Dr Fleming has judiciously suggested that the lapwing, which is so beautifully crested, may have been indicated under the old title of *egritte*. The true egret is not even alluded to as an indigenous bird so far back as the time of Willughby and Ray. The great egret (*Ardea egretta*, Temm.) is well known in Poland and Hungary, but scarcely ever shows itself in the western parts of the European continent.

The bitterns have the plumage of the neck extremely full and elongated. Their colours are usually brownish yellow, radiated or spotted with black. They form the modern genus Botaurus. The night-herons constitute another generic group, under the title of Nycticorax. The term, which signifies night-raven, has been no doubt applied from the circumstance of their feeding at night, and remaining in a state of comparative rest and inactivity throughout the day. The European species (*Ardea nycticorax*, Linn.,—*Nyc. Europeus*, Stephens) is more common in America than in the old world. New Holland and Africa each possesses a species. In form, Sir William Jardine observes, these birds are intermediate to the bitterns and true herons; the bill is short, and stronger in proportion than in either, and the hind head is adorned with (generally three) narrow feathers in the form of a crest. They feed by twilight, or in clear nights, and take their prey by wary watching, like the herons. They are gregarious and build on trees, and are noisy and restless during the period of incubation. The prevailing colours are ash-gray and black, or pale fawn and chesnut. The young are always of a dingier hue than their parents, and have their feathers marked with whitish spots.

The remaining genera of the *Cultrirostres* form Cuvier's third group.

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In the genus Ciconia, Cuv., the bill is large, without nasal groove or furrow, the nostrils pierced near the base, and towards the dorsal portion. The tarsi are reticulated, and the anterior toes strongly palmated, especially the external. The mandibles are broad and light, and when struck together produce a frequent and peculiar snapping sound, almost the only one they ever utter. The best-known European species is the white or common stork (*Ciconia alba*), a bird somewhat smaller than the crane, but larger than the heron. The bill and legs are red, the whole plumage pure white, except the greater coverts, scapulars, and quill-feathers, which are black. It is a common summer bird in several European countries, especially Holland, where it is esteemed and protected, and has become so familiar as to build on the tops of houses even in the centre of large towns. Its periodical migrations have long excited the admiration of naturalists by their extent and regularity. They are indeed beautifully and wisely directed. "Yea, the stork in the heavens knoweth her appointed times; and the turtle, and the crane, and the swallow, observe the time of their coming." The species appears to have been regarded with peculiar favour in almost all ages and countries. By the ancient Egyptians it was looked upon with a reverence only inferior to that which they paid to the mystical ibis; the same feeling still preponderates in many parts of Africa and the East; while nearer home the Dutch are remarkable for their affectionate attachment to this "household bird." On the other hand, the stork itself appears to reciprocate this friendly feeling. Undismayed by the presence of man, it builds its capacious nest upon the house-top, or on the summits of "ancestral trees" in the immediate vicinity of human dwellings, or even environed by the busiest haunts of men. "It stalks," says Mr Bennet, "perfectly at ease along the busy streets of the most crowded town, and seeks its food on the banks of rivers, or in fens in close vicinity to his abode. In numerous parts of Holland its nest, built on the chimney top, remains undisturbed for many succeeding years, and the owners constantly return with unerring sagacity to the well-known spot. The joy which they manifest in again taking possession of their deserted dwelling, and the attachment which they testify towards their benevolent hosts, are familiar in the mouths of every one. Their affection for their young is one of the most remarkable traits in their character. It is almost superfluous to repeat the history of the female which, at the conflagration of Delft, after repeated and unsuccessful attempts to carry off her young, chose rather to perish with them in the general ruin than to leave them to their fate; and there are many other and well-authenticated proofs of a similar disposition. They generally lay from two to four eggs, of a dingy yellowish white, rather longer than those of the goose, but not so broad. The incubation lasts for a month, the male sharing in the task during the absence of the female in search of food."[1]

Of the foreign species, the gigantic stork (*C. argala*) is well known in India by the name of adjutant. It measures upwards of six feet in height. A nearly allied species is the marabou of Africa (*C. marabou*, Temm.), very common in many parts of the interior. According to Major Denham, it is protected by the inhabitants on account of its services as a scavenger. Its appetite is most voracious, and nothing comes amiss to its omnivorous propensities. Mr Smeathman has given a long account of a bird of this kind which regularly attended at the dining table, and frequently helped itself to what it liked best. It one day darted its enormous bill into a boiled fowl, which it

[1] *Zoological Gardens*, ii. 21.

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swallowed so instantaneously that all hope of rescue was in vain. On another occasion it actually bolted a cat.

The genus MYCTERIA, Linn., contains the birds called *jabirus*. They scarcely differ from the storks, except in the bill exhibiting a slight curvature upwards. The species, if correctly referred to by naturalists, though few in number, inhabit widely distant regions,—*M. Americana* being native to Cayenne, *M. Australis* to New Holland, and *M. Senegalensis* to Western Africa. Is the latter synonymous with Dr Ruppell's saddle-billed stork, *C. ephippiorhyncha ?*

The genus SCOPUS is composed of a single species, *S. umbretta*, Linn., an African bird, of the manners of which we are still entirely ignorant. In English books it is called the tufted umber. Its generic title (Σκοπος) is Greek for sentinel. It is probably watchful and solitary.

The genus ANASTOMUS, of which the Pondicherry and Coromandel herons of Latham serve as examples, is peculiar to the East Indies. These species present a remarkable peculiarity in the structure of the bill. The mandibles touch each other only at their points and bases, thus leaving a gaping intervening space. *An. Coromandelianus* is common on the banks of the Ganges, and other eastern rivers, and likewise frequents the Coromandel coast during the months of September, October, and November, feeding on fish and reptiles. A more recently discovered species is *An. lamelligerus* of Temm. (*Pl. Col.* 236), a native of the Cape.

The genus DROMAS of Paykull has the bill compressed and swollen at the base beneath, with the commissures close. The only known species is *D. ardeola*, Temm. *Pl. Col.* 362, an African bird, with white plumage, the back and pinions, as well as the legs and bill, being black. It is of rare occurrence, but rather extended distribution, specimens having been obtained both from the shores of the Red Sea and the Senegal coast. "L'ardeole," says M. Lesson, "tient des œdicnèmes par son bec, et mêmes des sternes, de l'avocette, par son plumage et les tarses. C'est un véritable oiseaux de transition dans l'établissement des familles."[1] Some recent writers regard this bird as identical with the *corrira* so long ago described by Aldrovandi[2] as an Italian species, but not since seen either in Europe or elsewhere. The descriptions however do not accord. Bechstein, Vieillot, and others, think the Italian corrira a fictitious species, made up from the body of an avocet and the legs of a thick-knee'd plover; but Professor Ranzani is of opinion, that as its name is a vernacular one, and there is no proof that Aldrovandi possessed any stuffed birds (none being mentioned in the catalogue of his museum, and the art in those days being almost unknown), a well-known living species must have been alluded to. Indeed it appears that Charleton, at least seventy years after the printing of the Italian author's third volume, received a specimen from Merret of what he considered as the bird in question.[3] "Non vi ha al certo," observes Ranzani, "alcun giusto motivo di rivocare in dubbio, che al tempo di Aldrovandi si trovasse ne' luoghi vallivi del territorio Bolognese un uccello steganopodo, il quali venisse da' cacciatori chiamato corrira, perchè correva velocémente." "E quantunque," he afterwards adds, "oggidì niuno de' molti cacciatori Bolognesi da me consultati conosca la corrira, non cesserò io per questo dal farne le più diligenti ricerche, potendo benissimo accadere, ch'essa torni alcuna volta a visitare i nostri terreni vallivi."[4]

In the genus TANTALUS, Linn., the bill, nostrils, and feet resemble those of the storks, but the back of the upper mandible is rounded, its point curved a little downwards, and slightly notched on either side. A portion of the head, and sometimes of the neck, is bare of feathers. The species, formerly confounded with the ibises, are of large size, and inhabit Asia, Africa, and America. The best known is *Tantalus loculator*, called the wood ibis in the United States. It is white, with the face and head greenish blue, the quill and tail feathers black, with coloured reflections. It measures above three feet in length, and the bill itself is about nine inches long, very broad at the base. The wood ibis is a solitary indolent bird, seldom associating in flocks, but resting alone, like a feathered hermit, listlessly on the topmost limb of some tall decayed cypress, with his neck drawn in upon his shoulders, and his enormous bill resting like a scythe upon his breast. Thus pensive and lonely, he has a grave and melancholy aspect, as if ruminating in the deepest thought; and in this sad posture of gluttonous inactivity (for in truth he has only over-eaten himself) he passes much of his time, till aroused by the cravings of hunger. He feeds on snakes, young alligators, fish, frogs, and other reptiles, and wisely migrates southwards on the approach of winter.[5] In the United States the principal residence of this bird is in the inundated wilds of the peninsula of East Florida. The *Tantalus ibis* of Linn. is an African species, long erroneously regarded as the bird so highly venerated by the Egyptians; but it scarcely occurs in the country of the pyramids, being usually imported from Senegal. The other species of this genus are *T. leucocephalus*, from Ceylon and Bengal; and *T. lactea* (Temm. *Pl. Col.* 352), from Java.

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The last genus we shall mention of our present tribe is PLATALEA, Linn., containing the birds called spoon-bills, which, like the preceding, are also few in number. The chief character is constituted by the rounded flat enlargement or dilatation at the extremity of the bill, from which they derive their English name. They inhabit marshy and muddy places, where they grope about with their *spoons* in search of worms and mollusca. They are gregarious and migratory, build on trees, occasionally among rushes, and occur in Europe (*Pl. leucorodia*), Africa (*Pl. nudifrons*), and America (*Pl. ajaja*). The last-named species, called the roseate spoon-bill, is a beautiful bird, the ground-colour white, but richly tinged with rose-colour, deepening in part into carmine-red. The feet are half webbed, and the toes are very long. (See Plate XVI., fig. 2). This bird is more maritime in its habits than the European kind, and wades about the coast in quest of shell-fish and small crabs. According to Captain Henderson (in his account of Honduras), it occasionally both swims and dives. Although it now and then straggles up the Mississippi towards Natchez, into Alabama, and even as far north as the banks of the Delaware, it is a truly tropical bird, frequent in Jamaica and other islands of the West Indies, as well as in Mexico, Guiana, and Brazil. In a southerly direction, it is said to spread as far as Patagonia.

TRIBE 4TH.—LONGIROSTRES.

In this tribe the bill may be characterized as lengthened and feeble. The species belong chiefly to the old genera *Scolopax* and *Tringa* of Linn. They bear a general resemblance in their forms and habits, and frequent moist places, where their slender bills can probe for worms and insects, without the risk of fracture.

In the genus IBIS, Cuv., the bill is long, arched, broad, and squarish at the base, with the point depressed, obtuse, rounded, and the upper mandible deeply furrowed throughout its whole length. The nostrils are narrow and oblong,

[1] *Traité d'Ornithologie*, p. 591.
[2] *Ornithologia*, t. iii. p. 288.
[3] *Exercitationes de differentiis Animalium*, Oxonii, 1677, p. 102–3.
[4] *Elementi di Zoologia*, t. iii. parte ix. p. 300–2.
[5] Nuttall's *Manual*, vol. ii. p. 83.

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and pierced through the membrane of the furrow near its base. The forehead and lores are bare of feathers.

The species of this remarkable genus are distributed over the warmer zones of all the four quarters of the globe, the green or glossy ibis (*Ibis falcinellus*), being itself found in Europe, Asia, Africa, and America, and occasionally in Great Britain. The sacred or Egyptian ibis (*Ibis religiosa*, Cuv.,—*Tantalus Ethiopicus*, Latham) is a bird of a more striking and peculiar aspect, though undistinguished by much diversity in the colours of its plumage. It measures about two feet six inches in length. The head and neck are, in the adults, bare of feathers, presenting nothing but a dark cutaneous surface. The prevailing colour is white, with long funereal-looking plumes of a purplish black colour, proceeding from beneath the tertiary wing-feathers, and hanging down not ungracefully on either side. The legs and feet are deep lead-colour. Among the ancient Egyptians, a people prone to award divine honours to the brute creation, the ibis was regarded as an object of superstitious worship, and its sculptured outline frequently occurs among the hieroglyphical images which adorn the walls of their temples. The conservation of its mystical body occupied the assiduous care of their holiest priests while living, and exercised the gloomy art of their most skilful embalmers when dead. To slay or insult it would have been deemed a crime of the darkest hue, and sufficient to call down upon the offender the immediate vengeance of heaven. The incarnation of their gods was effected through the medium of this sacred bird, and the tutelary deity of Egypt was supposed to be thus imaged to the eyes of adoring mortals when he descended from the highest heavens. The embalmed bodies of this species are still found in the catacombs, and other places of ancient sepulture; and the antiquary and the naturalist marvel alike at the wonderful art which, for some thousand years, has handed down unimpaired to a far-removed posterity the form and features of so frail a creature. The perfection of an unknown process has almost defied the ravages of time, and through its intervention the self-same individuals exist in a tangible form, which wandered along the banks of the mysterious Nile in the earliest ages of the world, or "in dim seclusion veiled," inhabited the sanctuary of temples, which though themselves of most magnificent proportions, are now scarcely discernible amid the desert dust of an unpeopled wilderness.

The natural and mythological histories of this remarkable bird are so closely combined by ancient authors, that it is scarcely possible to gather from their statements any rational meaning. Those, indeed, whose province it is to illustrate the history of mankind, by explaining the rise and progress of superstition, and the frequent connection between certain forms of a delusive worship, and the physical conditions of clime and country, may find in the distorted history of Egyptian animals an ample field for the exercise of such ingenious speculations; but the Zoologist has to do rather with things as they are, than as they were supposed to be,—and his province is to explain (or attempt so to do) the works of the God of nature as they exist in their most beautiful and harmonious simplicity, undeformed by the multitudinous fables of a remote antiquity. We need not, then, to inquire whether the basilisk be born from an egg produced in the body of the ibis, by a concentration of all the poison of all the serpents which it may have swallowed in the course of a long and reptile-eating life;—nor whether the casual touch of its lightest plume still suffices not only to enchant and render motionless the largest crocodile, but even to deprive it at once of life;—nor whether the ibis itself, according to an expression of the priest of Hermopolis, sometimes attains to so great an age that "it cannot die," unless when, removed from the sustaining soil of its beloved Egypt, it sinks beneath the *nostalgia* of a foreign land! For we know that the basilisk does not exist; that young ibises have been seen flapping themselves across the outstretched bodies of sleeping crocodiles, which afterwards sought the waters of the Nile with their accustomed alacrity; and that the age of the sacred bird, though from the skill of the embalmers it may be said to be "in death immortal," does not exceed that of the rest of its congeners.

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The sacred ibis is usually observed either in pairs, or in small groups of eight or ten together. They build their nests on palms and other elevated trees, and lay two or three whitish eggs. They do not breed in Egypt, but arrive in that country when the waters of the Nile begin to swell. This apparent connection (as of cause and effect) between the presence of these birds and the fertilizing flow of the mighty and mysterious river, probably gave rise to their worship as divine agents in immediate connection with those grander processes of nature by which the surface of the earth was regulated, and sustained in a fit condition for the health and prosperity of the human race. A slight knowledge of natural history would indeed have sufficed to show, that such divine honours had not been awarded as a consequence of their destruction of serpents and other venomous reptiles; for the modern Egyptians confirm the views of Colonel Grobert, that the ibis does not prey on serpents at all, but feeds very much after the manner of the curlew, on insects, worms, small fishes, and molluscous animals.[1]

A smaller sized though much more splendidly attired species, is the scarlet ibis (*I. ruber*) of America. This brilliant bird is confined to the new world, where it is chiefly tropical, abounding in the West Indies and the Bahama Islands, and stretching southwards of the equator at least as far as Brazil. In the course of the summer (generally in July and August) it migrates into Florida, Alabama, Georgia, and South Carolina, retiring into Mexico and the Carribbean Islands on the approach of the winter season. It is gregarious, feeding along the sea-coast, the shores of estuaries, and the banks of rivers, on small fry, shell-fish, insects, and worms. Although they often perch on trees (where the contrast of their fiery plumage with the surrounding foliage is said to produce a most resplendent effect), they build their nests upon the ground. The young for several seasons exhibit obscure shades of brown, they afterwards become spotted with red, and then assume the splendid attire of the parents, which is a uniform and dazzling scarlet, with the exception of the extremities of the first four primaries, which are of a rich bluish black. Pennant says that the scarlet ibis has been domesticated in Guiana; and Dr Latham possessed one which was brought alive to England, and lived for some time with his poultry. It is clear from the statements of American writers, that it is, at least in temperate countries, a bird of passage, although Cuvier observes, "que cette espèce ne voyage point." When taken young it is easily tamed, and submits to domestication without repining. Delaet says it has even propagated in captivity; and M. Delaborde has given the history of an individual which he kept for above two years, feeding it on bread, raw or cooked meat, and fish. It was fond of hunting in the ground for worms, and was in use to follow the gardener in expectation of that favourite food. It roosted at night upon the highest perch in the poultry-house, and flew out at an early hour of the morning, sometimes to a great distance from home. Our climate is probably too cold and variable for a bird which

[1] Wilson's *Illustrations of Zoology*, vol. i. pl. xix.

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on the approach of winter always migrates southwards, otherwise it would assuredly form a splendid (it is even said a savoury) addition to our stock of domestic fowls.[1]

In the genus NUMENIUS, Cuv., the bill is arched, as in the preceding, but still more slender, and rounded throughout its entire length, instead of being square at the base. The extremity of the upper mandible extends beyond the under one, and projects a little over it at the base. There is an obvious palmation at the root of the toes.

To this genus belong the curlews,—well-known birds, of shy and wary habits, which, according to the season, haunt either the hilly pastures or the sandy shores. The North American species (*N. longirostris*, Wilson) is remarkable for the extraordinary length of its bill. (See Plate XVI., fig. 3.) The common curlew of Britain (*N. arquata*) seems to inhabit exclusively, during the breeding season, our upland moors and pastures, and descends to the sea-coasts in winter. The smaller British species, called whimbrel (*N. phæopus*), seems scarcely known in England during summer, but is then frequent in the north of Scotland, where it breeds. It is distinct from any of the American curlews,—with one of which, however, it has sometimes been confounded. A nearly allied species, first described by M. Vieillot under the title of *Numenius tenuirostris*, as a native of Egypt, has been ascertained by C. L. Bonaparte to exist in great numbers along the banks of the Tiber, where it occurs during winter. It has also been discovered by Signor Savi in the neighbourhood of Pisa, by Dr Pajola in the Venetian territory, and by Professor Bonelli in Piedmont. We doubt not it occurs occasionally in most parts of Europe (especially the eastern countries), although it escapes detection in consequence of its strong resemblance to the common whimbrel. Its distinctive phrase is—Numenius pileo cinerino e nigro maculato: pennis longioribus ilium candidis, immaculatis.[2] The small esquimaux curlew (*N. borealis*, Lath. and Richardson) passes over a vast extent of territory in its migrations,—breeding in the barren lands within the arctic circle, and spending the winter in Brazil.

In the genus SCOLOPAX, Cuv., containing the snipes and woodcocks, the bill is very long, but straight, and pervaded almost throughout its entire length by a nasal furrow. The upper mandible is slightly inflated at the tip, which is rather soft, and extremely delicate in its perceptions. The feet are not palmated. The head is compressed, the eyes large, and situate far back upon the head,—" ce qui," says Cuvier, " leur donne un air singulièrement stupide, qu'ils ne démentent point par leurs mœurs." Now, though the birds in question may want those accommodating instincts which elevate the character of many other species almost into a semblance of reason, we are not aware that they are in any way of defective intellect, that is, that their proceedings are at all discordant with self-preservation, the enjoyment of their natural propensions, or the continuance of their kind; and as to the position of the eye, whatever may be its physiognomical effect, is it not admirably adapted to their general modes of life, and their particular habit of plunging their bills into the mud of marshes, enabling them so to do, and yet to keep a sharp look-out around them? Depend upon it, their eyes are in the right place, and their large size cannot be otherwise than advantageous to birds which feed by night.

We have five British species of *Scolopax*, of which the woodcock (*S. rusticola*) is the chief, a bird much admired by epicures, who eat him, entrails and all,—a dirty practice, we opine: but, *de gustibus non disputandum est.* During the day this species usually frequents the closest brakes, where the ground, from depth of shade, is nearly free from herbage. They abound most in thickets by the sides of open glades, or where roads intersect; for by these they pass to and from their feeding ground at evening and the dawn of morn. " Unless disturbed," says Mr Selby, " they remain quietly at roost upon the ground during the whole day; but as soon as the sun is wholly below the horizon, they are in full activity, and taking flight nearly at the same instant, leave the woods and cover for the adjoining meadows or open land, over which they disperse themselves, and are fully engaged in search of food during the whole night. Advantage has long been taken of this regular mode of going to and returning from the feeding grounds by the fowler, in those districts where woodcocks are abundant, by suspending nets across the glades, or by the sides of hedges, where they are observed to pass continually; and though the adoption of the fowling-piece has in general superseded the modes of capture formerly practised, great numbers are still taken in this manner in Devonshire and Cornwall. Another method of entrapping woodcocks (as well as snipes) is by the springe, which is set in places where those perforations made by the bill of the woodcock in search of food, and technically called *borings*, are observed to be most frequent. It is formed of an elastic stick, of which one end is thrust into the ground, the other having affixed to it a noose made of horse-hair; the stick being then bent down, this noose is passed through a hole in a peg fastened to the ground, and is kept properly expanded by means of a fine trigger, so set as to be displaced by the slight pressure of the bird's foot. To conduct them to this trap, a low fence of twigs, or of stones placed so closely together as to leave no passage through the interstices, is extended to some distance on each side of the springe, and generally in an oblique direction; over which obstacle, however trifling, it seems the birds never attempt to hop or fly, but keep moving along it, till they approach the part occupied by the noose of the springe: upon attempting to pass through this apparently open space, they displace the trigger, and are almost invariably caught by the noose, and retained by the spring of the stick against the opposing peg. Day being the woodcock's time for repose, it sits very close, and is not easily *flushed;* the sportsman then requiring the aid of the busy spaniel, or the bush in which it is ensconced to be actually beaten by an attendant, before it will take wing. It rises, however, with much quickness, and threads its way through the branches with great rapidity, until the underwood and trees are fairly cleared, when its flight becomes measured, and offers an easy aim to the sportsman. When roused, it seldom flies to any great distance, but alights in the first thicket that attracts its attention, closing its wings, and dropping suddenly down, and in such cases it is not unusual for it to run a little way before it squats. Just before rising, upon being disturbed, or when running, it jerks its tail upwards, partly expanding it, and fully showing the white that distinguishes the under surface of the tips of the tail-feathers. In feeding, the woodcock inserts its bill deep into the earth in search of worms, which are its favourite and principal food. This instrument is most admirably calculated for the offices it has to perform when thus immersed in the soil; for, in addition to its great length, it possesses a nervous apparatus distributed over a great portion of its surface, and especially on such parts as are likely to come first into contact with its prey, giving it

[1] *Gardens and Menagerie of the Zoological Society.* We do not know how it has happened that the wood-cut of the scarlet ibis in the work just referred to is copied into Mr Nuttall's excellent *Manual of American Ornithology*, under the name of wood ibis, *Tantalus loculator*,—a bird which belongs to a different genus.

[2] *Ornitologia Toscana*, tom. ii. p. 324.

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the sense of touch in the highest perfection; and to enable it to secure the object thus detected by the discriminating sensibility of the bill, it is further provided with peculiar muscles (common, I believe, to all the members of the genus), which by compression of the upper or basal part of the bill, are brought into action so as to expand the tips of both mandibles sufficiently wide to lay hold of and draw forth the hidden treasure. The digestion of this bird is rapid, and the quantity of worms it can devour in the course of a night is astonishing. I have known one that consumed at a meal (that is, within the night) more large earth-worms than half filled a garden-pot of considerable size. It may, however, by management, be brought to eat other food; as Montagu mentions one that was induced to feed on bread and milk, by worms cleanly washed being put into a mess of that kind; and by this practice being persisted in, the bird soon acquired a relish for this new sort of aliment, and, with the addition of a few worms, throve well upon it."[1] We have already mentioned that the woodcock is now of frequent and constant occurrence as a breeding bird in several of the northern parts of Scotland.

Our other species of this genus are the common snipe, *S. gallinago*, Linn., which also occurs in the temperate parts of Asia; and the jack-snipe, *S. gallinula*, a winter visitant, which breeds, though sparingly, in the north of Scotland. Besides these, we have as occasional visitants,—the great or solitary snipe, *S. major*, Gmel., which haunts the vast marshes of the north of Europe,—and a species of which only one or two examples have been as yet discovered (it was first shot in Queen's county, Ireland, we believe in 1822), named *S. Sabini*, by Mr Vigors.[2] Although some of these birds have an extended geographical distribution, the great similarity of several species, both in size and plumage, has caused misapprehension. There is now no doubt that the species of Europe and America are quite distinct. The lesser woodcock, *S. minor*, is a beautiful bird, well known in the United States. The brown snipe of Pennant (*S. grisea*, Gmel.) forms the genus Macroramphus, Leach. Its toes are webbed at the base.

The genus Rhynchæa, Cuv., has the bill very similar to that of the snipes and woodcocks, but it is slightly arched towards the tip, and wants the furrow on that part. The toes have no palmation. The species are more richly coloured than their congeners, and, in consequence of their occasional variation, have been as yet but indifferently distinguished. The Cape species so called (*R. capensis*,—*Scol. capensis*, Gm., Plate XVI., figure 4), occurs in Java and the East Indies; while *R. variegata*, by some regarded as its young, has been received both from China and the south of Africa. A very distinct species, however (*B. hilarea*), described by M. Valenciennes, has been discovered in South America.[3]

In the genus Limosa of Bechstein, the bill is still longer than among the woodcocks, straight, or even slightly turned upwards, and pervaded by lengthened grooves, although the terminal single groove is wanting. The tip is blunt and depressed. There is a palmation at the base of the outer toes. The general form of the species is more slender, and the legs longer, than in the immediately preceding groups. They haunt more habitually saline marshes and the sea shore.

We here place the birds called *godwits*, of which we have two British species,—the black-tailed godwit, *L. melanura*, Leisler and Temm. (*Scol. ægocephala*, Linn.), and the red godwit, *L. rufa*, Briss. (*Scol. Lapponica*, Linn.). Of both of these birds the synonyms, till lately, were greatly confused, owing to the double moult to which they are subject, and which, producing a remarkable change in the nuptial plumage from that of autumn and winter, led to a corresponding multiplication of names,—each kind being described as two species, according to the season in which it was observed. Although the bill in the godwits possesses much of the general form of that of the woodcocks, it wants the extraordinary plexus of nerves, and therefore does not become rugose by exsiccation after death, but continues smooth and polished. It is also more solid, less flexible, and thicker towards the base. These birds inhabit marshes, and the banks and mouths of rivers, where the mud is soft and deep, and there they probe with their long extended bills in search of worms and insects. When thus engaged, they are frequently seen with their heads entirely under water; and we accordingly find them provided with that peculiar gland above the eye, of which the function appears to be to lubricate and defend that delicate and important organ from the irritating effect of saline waters.[4] The females considerably exceed the males in size. Several fine godwits, distinct from those of Europe, occur in North America; and a semi-palmated species, with a strongly recurved bill (*Scol. terek*, Lath.), is found both in India and Van Diemen's Land, and seems in some of its characters to lead towards the avocets.

In the genus Tringa of Temm., Selby, &c. (*Calidris* and *Pelidna*, Cuv.), the bill equals or is longer than the head, is straight or slightly arched, compressed at the base, the tip blunt, smooth, and dilated, semi-flexible, and furrowed throughout its length. The legs are of medium length, very slim, the feet four-toed, divided to the base, slightly margined, with the hind toe scarcely reaching to the ground.

The elegant and interesting species which compose this rather numerous genus are commonly known by the name of sea-larks or sandpipers, a term likewise bestowed upon the *Totani*. Many of them breed by the margins of lakes and rivers in the interior, although the majority congregate in autumn in numerous flocks along the sea coast. They moult twice a year, and their spring and summer plumage is generally very different from that of autumn and winter. This has occasioned great confusion in the history of several species. The sexes present no great disparity in point of plumage, but the females are of larger size. We coincide in Mr Selby's opinion, that the new genera *Calidris* and *Pelidna*, which Baron Cuvier has proposed in place of *Tringa*, are not so distinct or well defined as to warrant their adoption, being in fact only such slight modifications of form as might naturally be expected in birds placed at the extremes of the group to which they belong, and of which the intimate connection is shown by the intervention of species of intermediate form, leading gradually, almost imperceptibly, from one to the other. Besides, if these two generic groups are adopted, it would appear that *Tringa* would cease to exist as a recognised title, which is surely not in accordance with established rule. The species of our present genus are very widely distributed, and several are identical in Europe and America.

The dunlin or purre, *T. variabilis*, Temm. (*T. alpina* and *cinclus*, Linn.), is a strictly indigenous bird in Scotland, where it breeds both near the margins of our inland waters and along the sea-shore,—residing with us throughout the year. In America it penetrates during the summer season to the utmost habitable verge of the arctic circle, breeding on the desolate shores of Melville Peninsula. It likewise inhabits Greenland, Iceland, Scandinavia, and probably most of the coasts of Europe. We know that at least during winter it frequents the Italian shores. In the southern hemisphere it sometimes wanders as far as the Cape of

[1] *British Ornithology*, vol. ii. p. 110.
[2] *Linn. Trans.* vol. xiv. p. 556.
[3] Ferrussac's *Bulletin des Sciences*, 2d cah.
[4] Selby's *British Ornithology*, vol. ii. p. 94.

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Good Hope, and has been met with both in the West Indies and South America. When flying in great autumnal flocks, its aërial movements are extremely beautiful, each individual of the vast assemblage yielding so instantaneously to the same impulsion as to exhibit alternately the upper and the under surface of the body, so that we have for a time a living moving cloud of dusky brown, and then a brilliant flash of snowy whiteness.

The larger species, called the knot (*T. canutus*, Linn.), has also a vast range in a northerly direction. It passes the summer within the arctic circle, breeding in Melville Peninsula, and in Hudson's Bay, as far south as the fifty-fifth parallel. It lays four eggs of a dun colour, spotted with red, upon a tuft of withered grass. The knot winters in Britain, but many proceed much farther south, as we know they occur towards the end of autumn in the Venetian territory. The great mass of the North American knots pass over the United States, and spend the winter within the tropics. The other British species are *T. rufescens*, *Temminckii*, *minuta*, *maritima*, and *subarquata*.

The genus ARENARIA, Bechstein, closely resembles the sandpipers of the genus Tringa, but is distinguished by the entire absence of the hind toe. The only known species is the sanderling (*A. calidris*), one of our winter birds of passage, which breeds in the remotest northern regions, forming a rude grassy nest among the desolate marshes, and laying four dusky coloured eggs, spotted with black.

The genus FALCINELLUS, Cuv. (composed of *Scol. pygmæa*, Linn.), has the bill considerably arched, and the hind toe wanting. The only known species is an African bird, which occasionally makes its appearance in Europe. M. Temminck seems to think it should be regarded rather as a synonym than a distinct actual species.

The genus MACHETES, Cuv., bears a great resemblance to *Tringa*, except that there is an obvious palmation at the base of the toes. It contains only one species, commonly called the ruff (*T. pugnax*, Linn.), well known in the Lincolnshire fenns and the London markets (see Plate XVI., fig. 5). It is a summer bird of passage, arriving in the fenny districts of England in the month of April, and departing towards the end of September. The ruff, as its specific name implies, is a remarkably pugnacious species, a disposition which probably arises from its polygamous habits, in which it differs from its congeners. Some people say there are more males than females. Be this as it may, as soon as these birds arrive, each male fixes upon a small hillock or dry grassy spot among the marshes, where he keeps turning about till he has almost trodden it bare; but the moment a female makes her appearance, a general combat commences, the male birds lowering their heads, expanding their neck-feathers, and flying at each other with the action of fighting cocks. These battles are obstinate and long continued, and whoever proves the victor for the time obtains the female. They disperse at night for the sake of feeding, but every morning soon after daybreak each male returns to his hillock, where the same scenes of rivalry and love take place, and continue till their passionate fervour is abated, towards the end of June. The plumage of the ruff presents an almost infinite variety, scarcely two individuals being ever found precisely the same. The lengthened feathers of the head and neck are produced in spring, and shed towards the close of summer; and during autumn and winter the plumage becomes so different from that of the breeding season, that the birds would not be recognised as the same by any one previously ignorant of such mutation. Their flesh is highly esteemed as a delicate and nutritious food. Though these birds extend northwards as far as Iceland, and the colder parts of Russia, they never visit Scotland, the marsh of Prestwick Car, near Newcastle, appearing to be their British boundary. They occur, though rarely, in North America. Though their natural food is worms and water insects, they fatten soon in confinement on boiled wheat, or bread and milk mixed with bruised hempseed.

The genus HETEROPODA of Nuttall has the bill straight, rather enlarged and punctate at the extremity, the tarsus of moderate length, the three anterior toes connected at the base by a membrane. Example, *Tringa semipalmata*, Wilson. In the genus HEMIPALMA, Bonaparte, the bill is much larger than the head, partly arched, dilated, and studded at the tip with minute tubercles. The tarsus is very long, and the toes are usually connected by a membrane as far as the first articulation. The species are called stilt sandpipers, of which *H. himantopus* was discovered by C. L. Bonaparte and Mr Cooper. Both these genera are American.

In the singular genus EURINORHYNCHUS, Wilson, the bill is short, thin, depressed, spoon-shaped, the tarsi short, slender, reticulated. The only known species is a very rare and remarkable bird, *E. griseus*, native, it is supposed, both to Europe and America.[1] It was formerly classed with the spoon-bills (*Platalea pygmea*, Linn.), though scarcely larger than a sparrow. There is a specimen in the French Museum, which was accidentally killed near Paris. The plumage is gray above, white beneath.

In the genus PHALAROPUS of Brisson, the bill, though more flattened, resembles that of *Tringa*, but the toes are margined by a broadish membrane. In their habits the species are more aquatic than most of their congeners; for though they cannot dive, they float buoyantly on the surface, or even make their way by swimming with almost the ease of the regularly web-footed birds. The gray phalarope or scallop-toed sandpiper (*Phal. lobatus*, Flem.) is found occasionally in Britain during winter. It breeds habitually within the arctic circle, in Hudson's Bay, among the North Georgian Islands, and along the sterile shores of Melville Peninsula. According to Mr Bullock, it is not uncommon in the marshes of Sunda and Westra, the most northerly of the Orkney Isles. When seen swimming in pools, it is continually dipping its bill into the water, as if feeding on some minute aquatic creature. The plumage varies greatly with the season, and a variety of names have been bestowed in consequence of these mutations. The red phalarope (*Tringa fulicaria*, Linn.) represents the summer plumage. It was seen by our northern navigators on the 10th of June, in latitude 68°, swimming at its ease though several miles from land, but surrounded by mountains of ice.

In the genus STREPSILAS, Illiger, the legs are rather low, the bill short, and the toes without palmation as in *Tringa*, but the bill is conical and pointed, with the nasal fissure extending only one half its length. The hind toe nearly touches the ground. The only known species, *St. interpres* (of which *St. morinellus* is the young) is a winter bird of passage on the mainland of Britain, though it breeds and remains throughout the year among the Shetland Isles. The turnstone, as it is vernacularly called, is one of the most generally distributed of birds, being found at some season or other in almost every region of the globe. The English name is derived from its habit of turning over little stones along the shore in search of food, which it is enabled to do by its bill being proportionally stronger and stiffer than that of its congeners.

[1] *Acad. Suec.* 1816, pl. vi.

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In the genus TOTANUS, Cuv., the bill is slender, round, pointed, firm, the upper mandible slightly arched, with the nasal groove not extending above half its length. The form is light and active, the legs rather long, the toes webbed at the base, more especially between the outer and middle toe. In birds of this genus, as Mr Selby has observed, the comparatively hard and sharp-pointed bill indicates a corresponding change in habits and economy; so that instead of seeking their food by probing in the sand or softer mud, they search for it along the pebbly banks of lakes and rivers, or the ocean's gravelly shore. Some reside habitually in inland districts, while others prefer the sea-coast, or migrate thither during the autumnal season. The British species are the dusky sandpiper, *T. fuscus*, Leisler; the redshank, *T. calidris*, Bechst.; the green sandpiper, *T. ochropus*, Temm.; the wood sandpiper, *T. glareola*, Temm.; the common sandpiper, *T. hypoleucos*, Temm.; and the greenshank, *T. glottis*, Bechst. Besides which, the spotted sandpiper, *T. macularia* (a very common species in North America), &c. are of occasional occurrence. Regarding the last-named species, Mr Bartram informed Alexander Wilson, that he saw one of these birds defend her young for a considerable time from the repeated attacks of a ground squirrel. The scene of action was on the river shore. The parent had thrown herself, with her two young behind her, between them and the land; and at every attempt of the squirrel to seize them by a circuitous sweep, she raised both her wings in an almost perpendicular position, assuming the most alarming aspect possible, and rushing forwards on the squirrel, which for a time drew back intimidated; but soon returning, was met as before by the affectionate but infuriated bird, her wings and whole plumage bristling up to twice their natural size. This interesting, but, for one of the parties, fearful play, continued for about ten minutes, when the strength of the bird began to flag, and the attacks of the quadruped became more audacious, on which Mr Bartram interfered, "like one of those celestial agents," says Wilson, "who in Homer's time so often decided the palm of victory"! The green-shank (*T. glottis*), though usually regarded as merely a passenger in spring and autumn, is now known to breed in Scotland. It inhabits the northern parts of both continents, but is rarer in the new world than the old. Mr Audubon traced it as far south as the Tortugas, near the extremity of East Florida, and Latham received it from Jamaica. It also occurs in Bengal. Our common red-shank (*T. calidris*) is found occasionally in North America. A large species well known in the western world by the name of *willet*, and characterized by all the anterior toes being conspicuously webbed at the base, forms M. Bonaparte's genus CATOPTROPHORUS. This bird not only wades, but swims. It is the semi-palmated snipe (*Scol. semi-palmatas*) of the older systems.

The genus LOBIPES of Cuvier combines the bill of the preceding genus (*Totanus*) with the lobated toes of *Phalaropus*. We may mention as an example the red-necked phalarope,—*Tringa hyperborea*, Linn. (*Lob. hyperborea*, Cuv.), a species not uncommon among our northern islands, where it swims with great ease,—resembling when in the water a beautiful miniature representation of a duck. It likewise breeds all along the forlorn shores of arctic America, resorting to Hudson's Bay in autumn. Another species (*L. Wilsonii*) seems confined to the new world, where it breeds on the banks of the Saskatchewan, and occurs at least as far south as Mexico. It does not advance to so high a northern latitude as the hyperborean species, being as yet unknown beyond the fifty-fifth parallel. It forms an artless nest within the shelter of some grassy tuft, laying two or three pear-shaped eggs, of a tint between yellowish gray and cream colour, interspersed with small roundish spots, and a few larger blotches of umber-brown towards the obtuser end. It can only be regarded as a straggler in the United States. This bird forms the subgenus HOLOPODIUS of Bonaparte, the basal web between the inner and middle toe being less than in the preceding species. The synonyms of both are still somewhat confused.

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The genus HIMANTOPUS, Brisson, has the bill round, slender, pointed, the nasal furrow extending only half its length. But the principal and most peculiar character consists in the enormous length of the leg and tarsus, from which the species have derived the title of stilts, or long-legged plovers. The toes are united by a basal web, larger on the outer than the inner portion of the foot. These birds have a greater predilection for the borders of the sea, and for brackish lakes, than for the banks of rivers or pure fresh-water lakes. Their movements are rapid on the wing, but their gait is somewhat staggering, from the disproportionate length of their legs. The kind which occurs in Europe (*Him. melanopterus*, Meyer), called the black-winged stilt, has been known to breed in France, and accidentally visits England, but its chief resorts are the great salt marshes of Hungary and Russia. It is often seen in Italy in little flocks in spring, travelling northwards. It likewise occurs in Asia, Africa, and America; but the species of the new world, described by Wilson, is the *Him. nigricollis* of Vieillot. We shall here quote his account of its manners and mode of nidification, as the history of the European stilt, in these particulars, is scarcely known. "This species arrives on the sea-coast of New Jersey about the 25th of April, in small detached flocks of twenty or thirty together. These sometimes again subdivide into lesser parties; but it rarely happens that a pair is found solitary, as during the breeding season they usually associate in small companies. On their first arrival, and indeed during the whole of their residence, they inhabit those particular parts of the salt marshes pretty high up towards the land, that are broken into numerous shallow pools, but are not usually overflowed by the tides during the summer. These pools or ponds are generally so shallow that with their long legs the avocets can easily wade them in every direction; and as they abound in minute shell-fish, and multitudes of aquatic insects and their larvæ, besides the eggs and spawn of others deposited in the soft mud below, these birds find here an abundant supply of food, and are almost continually seen wading about in such places, often up to the breast in water.

"In the vicinity of these bald places, as they are called, fifty yards off, among the thick tufts of grass, one of these small associations, consisting perhaps of six or eight pair, takes up its residence during the breeding season. About the first week in May they begin to construct their nests, which are at first slightly formed of a small quantity of old grass, scarcely sufficient to keep the eggs from the wet marsh. As they lay and sit, however, either dreading the rise of the tides, or from some other purpose, the nest is increased in height with dry twigs of a shrub very common in the marshes, roots of the salt grass, sea-weed, and various other substances, the whole weighing between two and three pounds. This habit of adding materials to the nest after the female begins sitting, is common to almost all other birds that breed in the marshes. The eggs are four in number, of a dark yellowish clay colour, thickly marked with large blotches of black. These nests are often placed within fifteen or twenty yards of each other; but the greatest harmony seems to prevail among the proprietors. While the females are sitting, the males are either wading through the ponds or roaming over the adjoining marshes; but should a person make his appearance, the whole collect together in the air, flying with their long legs extended behind them, keeping up a continual yelping note of *click, click, click*. Their flight is

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steady, and not in short, sudden jerks, like that of the plover. As they frequently alight on the bare marsh, they drop their wings, stand with their legs half bent, and trembling, as if unable to sustain the burden of their bodies. In this ridiculous posture they will sometimes stand for several minutes, uttering a curring sound, while, from the corresponding quiverings of their wings and long legs, they seem to balance themselves with great difficulty.

"This singular manœuvre is, no doubt, intended to induce a belief that they may be easily caught, and so turn the attention of the person from the pursuit of their nests and young to themselves. The red-necked avocet practises the very same deception, in the same ludicrous manner, and both alight indiscriminately on the ground or in the water. Both will occasionally swim for a few feet, when they chance in wading to lose their depth, as I have had several times an opportunity of observing."[1]

The singular birds called avocets form the genus RECURVIROSTRA, Linn. Their feet are almost as fully palmated as those of certain Natatores, yet they are generally classed among the Grallatores, by reason of their lengthened tarsi, and legs bare above the knee. The bill also has the same lengthened, slender, pointed form, and smooth elastic structure, which characterize our present order, with which the birds in question agree in their general mode of life. The character which distinguishes them from all other birds is the extraordinary upward curvature of the bill (See Plate XVI., figure 6.) The avocets live either in pairs or small companies in the midst of marshes, where they wade about with great ease, and to a considerable depth, in consequence of their bodies being raised so high above the surface. Though web-footed, they do not swim except by compulsion; yet one which Wilson wounded attempted repeatedly to dive, but the water was too shallow for his purpose. They run rapidly, and their flight is powerful and long sustained. Their nests are described as small cavities in the earth, lined with a few weeds, or merely the bosom of the bare sand; sometimes, however, they are raised several inches above the surface, as if to avoid the effects of moisture or inundation. The European species (*R. avocetta*, Linn.) is not uncommon along the eastern coasts of England south of the Humber. It breeds in the fenny parts of Lincolnshire and Norfolk, as well as in Romney Marsh in Kent. They assemble during winter in small flocks, frequenting the oozy shores about the mouths of rivers, where they scoop out small worms and mollusca. Buffon indulges in one of his characteristic vagaries while discussing the singular bill of this bird, which he supposes to be "one of those errors or essays of nature, which, *if* carried a little further, would destroy itself; for *if* the curvature of the bill were a degree increased, the bird could not procure any sort of food, and the organ destined for the support of life would infallibly occasion its destruction." This essay of nature is, however, as it happens, a most successful one; for by means of its lengthened legs and upturned bill, the avocet feeds with facility in muddy marshes, where if otherwise organized it would probably starve. *If* a devoted servant of God, while tonsorially engaged on some beautiful Sabbath morning, were to move the edge of his glittering blade an inch nearer his carotid artery, he would die, leaving behind him, in all probability, a disconsolate widow, and a large family of small children; but as he takes especial care to move his useful weapon in another direction, the artery remains intact, and the crime of suicide unaccomplished. We doubt not that the curvature of the bill in question could not have been better projected even by Buffon himself, although he was addicted in his youth to mathematics. The American avocet (*R. Americana*, Linn., Plate XVI., figure 6) has the head and neck pale rufous, and the bill takes a downward curve towards the extremity. Though abundant on the banks of the Saskatchewan, as far as the fifty-third parallel, it does not seem to proceed into the more northern regions. Besides these species, there are the *R. alba* of Latham (*R. orientalis*, Cuv.), from India; and the *R. rubricollis*, Temm., a native of New Holland. Our indigenous species also occurs both in Asia and Africa.

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FAMILY V.—MACRODACTYLES.

The prevailing character of this group consists in the extremely long narrow form of the toes, which are without any connecting web. Nevertheless the species run with great ease in moist places, and some of them swim very swiftly. The bill, more or less compressed laterally, varies in length in different genera, but is never so delicately slender as among the preceding family. The body in these birds is much compressed, a form determined in a great measure by the narrow nature of the sternum. The wings are of medium length, or short; and the power of flight, though necessarily efficient in such as are birds of passage, is on the whole restricted, or but sparingly exercised. The posterior toe is of considerable length.

The first genus, called PARRA by Linnæus, contains the jacanas, by some named spur-winged water-hens. The bill is rather longer than the head, nearly straight, laterally compressed, and somewhat enlarged both above and below towards the extremity. There is usually a small fleshy shield upon the base of the forehead. The toes are of great length, very narrow, unwebbed, and the claws, especially the hinder one, very long and sharp (See Plate XVI., fig. 7.) The anterior angle of the wing is armed with a spur. The jacanas occur in the warmer countries of the world—in Bengal, Java, the Celebes, China, South America, and parts of Africa. They inhabit marshy places, and run with great facility over the surface of aquatic plants, their long, extended toes spreading over so much space as to prevent their sinking in the water. They feed on insects, build their nests among the moist herbage, and lay four or five greenish eggs spotted with brown. Their flight, though low, is rapid. They are shy and silent birds, except at night, when their voices are often heard among the marshes. The Chinese jacana of Latham (*Parra sinensis*, Gmelin) is found both along the marine shores and the moist plains of the interior. This species, as Mr Gould observes, is distinguished not more by grace and beauty of form, than by its admirable adaptation to the particular localities to which nature has allotted it. Formed for traversing the wide morass, or lotus-covered surface of water, it supports itself upon the floating weeds and leaves by its extraordinary extent of toes and unusual lightness of body. Like our common water-hen, of whose habits and manners it partakes largely, it is no doubt capable of swimming, although the long and pendent tail-feathers seem an inconvenient appendage for such a purpose. Its powers of flight appear deficient, the quill-feathers being terminated by a slender process proceeding from the tip of each shaft. This singular bird has been long known as a native of the low lands of India and other eastern countries, but was not till lately ascertained to occur in the Himalaya, where it inhabits lakes and swamps among the hills.[2] Another eastern species (*P. gallinacea*, Temm. *Pl. Col.* 464) is provided with a crest, but wants the spurs upon the wings.

In the genus PALAMEDEA, Linn., the bill is rather short, conical, compressed, convex, and curved at the extremity. There is a bare space around the eyes, the wings are am-

[1] *American Ornithology*, vol. iii. p. 76.

[2] *Century of Birds from the Himalaya Mountains.*

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ple, furnished with strong spurs. The tarsi are short and thick, the toes and claws long. Some systematic writers include in this genus only a single species, *P. cornuta*, Linn., called kamichi or the horned screamer, a South American bird, larger than a goose, with a slender moveable horny projection on the forehead. Though this bird affects inundated places, its toes are without palmation. In its general aspect, and several of its special habits, it exhibits an approach to the gallinaceous order; and although its stomach is but slightly muscular, it lives much on grain and herbage.[1] It is also easily reduced to the domestic state; and although it lays only two eggs, the young speedily follow the parents.

It is by no means easy to conjecture the natural uses of these formidable weapons on the wings of this and several other species. One would suppose them intended to wage war among their kind,—yet the birds so endowed are for the most part peaceable, and averse to broil and battle,—even in most instances of a timid and fearful nature; and in the case of several of the plover tribe, there is no appreciable difference in the habits of the armed and unarmed kinds. All who have studied the manners of the kamichis agree that they are the gentle inhabitants of moist savannahs, or the shores of those extensive rivers which intersect the southern portion of America, and that there is nothing pugnacious in their temper. Yet they are "doubly armed," the margin of each wing bearing a pair of very large spurs, thick at the base, but tapering sharply to a point, and, no doubt, when driven forcibly forward by the muscular action of a powerful wing, capable of inflicting such a blow as would at once deprive most small animals of life.

Another bird, by some referred to our present genus, is *Pal. chavaria*, Temm. (*Pl. Col.* 219), the *Parra chavaria* of Linn., known in some English works as the faithful jacana. Instead of a horn, its head is ornamented by a feathered crest, and there is an obvious palmation between the outer and middle toes. For these and other reasons it forms the genus Chauna of Illiger. Its head and upper neck are clothed with down, the latter being surrounded by a black collar. The rest of the plumage is lead colour and blackish, with a white spot upon the front of the wings, and another on the base of the primaries. Linnæus, on the authority of Jacquin, gives the following history of this bird:—"It inhabits the rivers, lakes, and marshes, near the river Sinu, about thirty leagues from Carthagena, in South America. It feeds on vegetables; its gait is solemn and slow, but it flies easily and swiftly; it cannot run unless assisted by the wings at the same time. When any part of the skin is touched by the hand, a crackling is felt, though it is very downy beneath the feathers; and this down adheres so closely as to enable the bird at times to swim, notwithstanding the length of its legs and of its cleft feet; which latter enable it also to walk on the aquatic plants of the pools. It has two strong and pointed spurs on the bend of the wing, which are, however, hidden when the latter is closed, but when expanded they become formidable weapons, aided by the strong and lengthened wing; and by means of them it is able to drive off birds as big as the carrion vulture, and even that bird itself. The natives, who keep poultry in great numbers, have one of these tame, which goes along with the flock about the neighbourhood to feed during the day, when this faithful shepherd defends them against birds of prey: it never deserts the charge committed to its care, although able to fly, but returns home with them safe in the evening. It is so tame as to suffer itself to be handled by a grown person, but will not permit children to attempt the same. Its voice is clear and loud, but far from agreeable."[2]

Baron Cuvier here places the genus Megapodius, Quoy et Gaim., of which the bill is slender, straight, flattened, and enlarged at the base, restricted at the centre, and inflated towards the point. The tail is small and wedge-shaped. The general form is massive, the plumage usually brown, without lustre. The species inhabit New Guinea, the Marianne Islands, &c. and are described in the voyages of Freycinet and Duperrey. They are remarkable for the largeness of their eggs. Some authors place them with the genera *Crax* and *Penelope*, rather than in the grallatorial order.

The extensive genus Rallus, Linn., is in one or other of its forms known in almost every country of the world. With Bechstein, we would restrict the title to such as have the bill longer than the head, rather slender, compressed at the base, with the tip cylindrical, and slightly curved. As a British example may be mentioned our common water-rail (*R. aquaticus*), a shy and solitary bird, which resides throughout the year in Britain. It is extensively spread over Europe, but does not occur in America. The land-rails form the genus Crex, Bechstein, and have the bill shorter than the head, thick at the base, somewhat cultrate, and compressed. The wings are armed with a small concealed spine. Besides the well-known corn-crake (*C. pratensis*), a summer bird of passage, of which the deceptive note is heard so often during evening twilight, we have the spotted crake, *C. porzana*, Baillon's crake, *C. Baillonii* (Olivaceous gallinule of Mont.?), and the little crake, *C. pusilla*. The Carolina rail seems a *Crex* in the form of its bill, though its aquatic habits assimilate it to *Rallus*. It assembles during autumn in vast numbers on the reedy shores of the larger rivers in the middle and southern states of North America, and affords abundant occupation to sportsmen. Any active and expert marksman may kill ten or twelve dozen in a few hours. It winters to the south of the Union. The diet of the different species probably varies with time and place. The American bird just named is very fond of rice. Our own species feed both on grain and insects. Sir W. Jardine found a short-tailed field-mouse in the stomach of a land-rail. This bird is called king of the quails in some continental countries, in consequence of its arriving and departing with these birds.

The old genus Fulica, Linn., has, like the preceding, been also subdivided, in accordance with the form of the bill and lobation of the toes. For example, the genus Gallinula of Briss. and Lath. has the bill resembling that of *Crex*, but there is a flat fleshy shield upon the forehead. The toes are long, and bordered by an extremely narrow lateral margin. We here place our British gallinule, familiarly known by the name of water-hen, *G. chloropus*, Lath. This bird, though with us a permanent resident, is migratory in all the more northern parts of Europe. It occurs both in Asia and Africa, but not in America, as some erroneously suppose. It swims and dives well, though its feet might, *a priori*, be deemed but little fit for such aquatic service. The water-hen is of rather familiar habits, that is, a pair are sure to make their appearance as soon as any small artificial piece of water has been formed, even in the closest proximity to human dwellings. It builds by the water-side, and lays a great number of eggs, from eight to ten, which it is said to cover carefully during its occasional absence in search of food. The purple and Florida gallinules (*G. Martinica* and *galeata*) occur in North America; and a Javanese species (*G. ardosiaca*) is described by M. Vieillot.

In the genus Porphyrio of Brisson, the bill is higher in relation to its length than in the preceding. The toes are extremely long, with scarcely a perceptible bor-

[1] Bajon, *Mém. sur Cayenne*, t. ii. p. 284.

[2] Shaw's *General Zoology*, vol. xii. p. 272.

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der; and the frontal disk, sometimes rounded, sometimes square above, is of considerable size. The species are remarkable for richness of colouring. *P. hyacinthinus*, Temm. (*Fulica porphyrio*, Linn.), is an African species, not unfrequent in Sicily and Sardinia.

The genus FULICA, as now restricted, is chiefly distinguished from its congeners by a scallop-shaped or broadly-festooned membrane on each side of the toes. It contains the coots, of which *F. atra*, Linn., our common coot, affords a good example. This bird, as generally distributed in Britain throughout the summer season as the water-hen, leaves the northern portions of the island on the approach of winter. It dislikes being approached in open water, though a good diver, and quickly betakes itself to some protecting cover of reeds or other water-plants on every slight alarm. The cinereous coot of the western world (*F. Americana*, Gmel.) is a distinct species, though not so regarded by Alexander Wilson. It is widely spread over a vast extent of territory, from the steaming marshes of Jamaica to the cool and grassy lakes which skirt the plains of the Saskatchewan.

Baron Cuvier terminates his systematic exposition of the grallatorial order by three genera of a somewhat anomalous nature, which certainly do not amalgamate either with their neighbours or each other.

The genus CHIONIS of Forster has the bill short, strong, compressed, the nostrils tubular, and protected by hard, elevated, and compressed folds, which envelope the base. (Plate XVI., fig. 8.) The front of the head and part of the face are naked, the wings long, the feet short. There is only a single species known. It is called the sheath-bill, *Ch. Forsteri*, or *necrophaga*, or *vaginalis*, and is of snowy whiteness, and of the size of a pigeon. A great diversity of opinion exists regarding its position; some writers removing it into the ensuing order, while Mr Swainson places it among the Columbidæ. It inhabits New Zealand, Kerguelen's Land, Staten Land, and other countries of the southern hemisphere, where it is said to frequent the seashore in flocks, feeding on mollusca and carrion, which latter renders its flesh offensive to the taste. It was discovered during Cook's circumnavigation.

The genus GLAREOLA, Gmel., contains the pratincoles, or sea-partridges as they are sometimes called. The bill is short, compressed, somewhat arched throughout, and rather deeply cleft. The wings are of great length, and very sharp pointed, somewhat resembling those of swallows. The legs are of medium length, and there is a slight palmation between the outer and middle toes. The tail is usually forked. These birds fly in numerous noisy flocks, and feed on insects, "particulièrement des mouches et autres insectes ailés qui vivent parmi les joncs et les roseaux; il se lance" (M. Temminck alludes particularly to the European species) "sur ces insectes avec une rapidité étonnante, et les saisit au vol ou à la course."[1] The pratincoles inhabit the temperate and warmer regions of the old world, and are unknown in America. The collared or Austrian species (*G. torquata*, Meyer) is common in the south-eastern countries of Europe, and has been killed occasionally in Britain.[2] *G. lactea*, Temm., inhabits Bengal;[3] *G. grallaria* of the same author is native to New Holland.

Lastly, the genus PHŒNICOPTERUS, Linn., contains those extraordinary birds called flamingoes. The bill is higher than wide, dentated, conical towards the point, the upper mandible suddenly bent from its centre downwards upon the under one, which is the broadest. The neck and legs are of extraordinary length, and the anterior toes are united by a broad palmation. Mr Swainson regards this genus as the grallatorial type of the *Anatidæ*, and he consequently places it in the natatorial order, which we are just about to enter. The only species known in Europe is *Ph. ruber*, Linn., a bird well known in Sicily and Calabria, and very abundant in Sardinia, especially among the lagunes and marshes in the neighbourhood of Cagliari. Large flocks occur almost every year along the southern coasts of France, and a few sometimes stray as far northwards as the banks of the Rhine. It is common in many countries of Africa and Asia; but the American species, regarded as synonymous by Wilson, is a distinct kind, mentioned long ago as such by Molina. (See Plate XVI., figure 9.) It is the *Ph. Americanus* of Mr Nuttall, and the bird alluded to by Thomas Campbell in his Gertrude of Wyoming:—

> Then, where of Indian hills the daylight takes
> His leave, how might you the flamingo see
> Disporting like a meteor on the lakes.

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Another western kind occurs in South America (*Ph. ignipalliatus*, Isid. Geoff.),[4] while a fourth (*Ph. minor*) is native to the Cape and Senegal.[5] These birds in general inhabit solitary sea-coasts in most of the warmer regions of the earth, where they associate in flocks, and migrate in bodies formed into an angular phalanx, like wild geese. They feed upon mollusca, insects, and spawn, which they fish up by means of their lengthened necks, sometimes turning their bill upside down, to take advantage of its peculiar, and apparently inconvenient form. They are said to be extremely shy and watchful (although Dampier and his two companions succeeded in killing fourteen at once[6]), and place sentinels, which on the approach of threatened danger, give alarm by a loud and trumpet-like cry. They also breed together in inundated marshes, raising their nests to a considerable height, by collecting the mud into a pyramidal hillock with their toes, after which they brood and hatch their eggs in what may be called a standing posture, their feet and legs being often in the water. The young are only two or three in number, and run almost as soon as excluded from the shell. They sleep standing upon one leg, with the neck folded back upon the body, and the head reclined beneath the wing. They run swiftly, but never swim from choice.[7] The tongue of the European flamingo was much admired by ancient epicures; and Apicius, that "deepest abyss of wastefulness," as Pliny calls him, is supposed to have been the first to discover its exquisite flavour.

ORDER VI.—PALMIPEDES, OR WEB-FOOTED BIRDS.[8]

The birds of this order are especially characterized by their peculiar adaptation for swimming, their feet being generally short and placed far behind, their tarsi short and compressed, and their anterior toes connected by membranes,

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[1] *Manuel*, ii. p. 502.
[2] Bullock, in *Linn. Trans.* xi. 177.
[3] See *Planches Col.* 399;—also Leach in *Linn. Trans.* xiii. pl. 12.
[4] *Annal. des Sciences Nat.* xvii. 454.
[5] Temminck, *Pl. Col.* 419.
[6] *Voyage*, i. 70.
[7] Nuttall's *Manual*, ii. 70.
[8] NATATORES, Illiger.

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or inlayed by lateral lobes. Their plumage is close, often glossy, and imbued with an oily fluid, which repels the water; and their skin is moreover covered with a dense layer of down, which prevents the rapid escape of the heat generated in their bodies. They are the only birds whose neck exceeds their legs in length, the reason of which arrangement is, that while swimming on the surface of the water they have often to search for their food at some depth. Their sternum is elongated so as to cover the greater part of the viscera, and has only a lateral notch, or oval foramen, so that a large surface is afforded for the insertion of the pectoral muscles. Their œsophagus is always wide, their gizzard generally muscular, and their intestine furnished with two rather long cæca. Their windpipe varies in form, but the inferior larynx is simple, although in one family it has a curious bony and cartilaginous dilatation.

This order has been divided into four families:

1. The *Brachypteræ*, or short-winged sea-birds, having the wings very short, and the feet placed so far behind that they are obliged to assume a nearly erect posture when on shore.

2. The *Longipennæ*, or long-winged sea birds, having the wings extremely long, the hind toe free or wanting, and the bill horny.

3. The *Totipalmæ*, of which the hind toe is connected with the rest by a common web, the wings long, and the bill horny.

4. The *Lamellirostres*, whose bill, which is thick and covered with a soft skin, has the edges furnished with transverse horny plates or teeth.[1]

FAMILY I.—BRACHYPTERÆ, OR DIVERS.

The organization of these birds renders them more aquatic than those of any other family. Many of them reside almost entirely on the waters, fly little, and walk with difficulty, their feet being placed very far behind. Their wings are generally extremely short, and their flight, although sometimes rapid, is neither undulated nor buoyant. In some species they are reduced to mere organs of natation, the quills not being developed. All the species are furnished with a dense and short plumage, swim and dive with remarkable agility, and pursue their prey under the surface, employing their wings as well as their feet to aid their progress. They are generally distributed, migrate extensively, and breed in society, often on rocky islands or abrupt cliffs. This family may be divided into three tribes.

1*st*. The divers,—*Colymbidæ*, are characterized by their straight, compressed, pointed, smooth bill, linear and lateral nostrils, narrow wings, and short tail. In some the feet are lobed, in others webbed.

The grebes, genus Podiceps (Plate XVII., fig. 1), resemble the coots in the form of their feet, their anterior toes, instead of being connected by webs, being merely dilated by means of lateral lobes. Their body is generally short and depressed; their neck long and slender; their bill straight, compressed, tapering, and pointed; their nostrils linear and pervious. The legs (tibiæ) are entirely concealed in the abdomen; the tarsi are extremely compressed; and the claw of the middle toe is flattened and dilated. The plumage is remarkably soft, silky, and often, especially on the lower part, has a shining gloss. Their wings are very narrow, and their tail is generally reduced to a slight tuft of scarcely distinguishable feathers. These birds when on shore are obliged to stand in a nearly erect posture; but although they walk with difficulty, their flight is rapid, and their motions on the water extremely quick. They dive and pursue their way under water with extreme agility, and when apprehensive of danger generally disappear under the surface, instead of flying off. Their food consists of small fishes, crustacea, mollusca, and insects, as well as seeds of aquatic plants; and they nestle in marshy places, laying several eggs, generally of a white colour. Their plumage varies so much, according to age and sex, that the species have been erroneously multiplied by authors. Four species inhabit Europe, of which two may be particularly mentioned.

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The great crested grebe, *Podiceps cristatus*, is of the size of a mallard, blackish brown on the upper parts, with a white band on the wing, and of a silvery white beneath. The adults have a double black crest, and a large reddish ruff or tippet margined with black, on the upper part of the neck. This species inhabits the northern part of both continents, where it breeds, and whence it migrates southward on the approach of winter. The nest is made of rushes and flags, or other aquatic herbage; and the eggs, three or four in number, are of a greenish white. Several authors allege that the female sometimes succours her young, when fatigued or in danger, by carrying them on her back or beneath her wings. From their surprising agility in diving they are not inappropriately named water-witches and dippers in America. The skins are dressed and made into muffs and tippets.

The little grebe, or dobchick, *Podiceps minor*, is the smallest of the species, not exceeding ten inches in length. It is not uncommon in most parts of Europe, as well as in the north of Asia, and the country around Hudson's Bay. In large rivers and lakes individuals are said to be sometimes devoured by pike and other fishes. In the adult the upper parts are deep black, the lower silvery gray, the throat black, and the neck ferruginous.

The finfoots, Podoa, Illig., have the feet lobed like the coots and grebes; but their tail is more developed, and their claws more pointed. (Plate XVII., fig. 2.) To this genus have been referred the African finfoot, *P. Senegalensis*, and the Surinam species, *P. Surinamensis*, which latter, however, is by some considered as belonging to *Anhinga*.

The divers properly so called, genus Colymbus, greatly resemble the grebes in form, but differ from them in having the toes regularly webbed, and the tail moderately developed. Their body is elongated, and somewhat depressed; their neck long, their head small, oblong, and compressed; their bill rather long, straight, and tapering to a point; their plumage short and close; their wings of moderate length, but very narrow. These birds are peculiarly aquatic, and while in search of food remain often longer submerged than on the surface, to which they seem occasionally to come merely for the purpose of respiring. They feed on fishes of various kinds, but generally of small size, as well as on crustacea. Like the grebes, they dive when alarmed, and are not easily raised from the water, although their flight, which is direct, is very rapid. On land they stand erect, and walk with difficulty. They are generally solitary, breed on the margins of lakes in the arctic regions, and lay two or three very elongated, dark-coloured, and spotted eggs. Their flesh is dark-coloured and unsavoury. Of this genus the more remarkable species are the following.

The great northern diver, *Colymbus glacialis*, is about two feet and three quarters long, with the upper parts black, spotted with white; the head and neck glossy black, with green reflections, the lower parts white; the tail has twenty feathers. This species is generally distributed in

[1] For some interesting general observations on certain genera of this order, the reader may consult "Remarks on the Pelagic Birds, and on certain other Palmipedes, considered especially as regards their habits and their geographical distribution in the Oceans of the Globe," published in Freycinet's *Voyage autour du Monde,—Partie Zoologique*, par MM. Quoy and Gaimard.

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the cold and temperate climates of the northern hemisphere. It breeds in the arctic regions, generally on the margin of lakes, or on islands, laying three eggs of a dull olive tint spotted with dusky. "Far out at sea in winter," says Nuttall, "and in the great western lakes, particularly Huron and Michigan, in summer, I have often heard, on a fine calm morning, the sad and wolfish call of the solitary loon, which like a dismal echo seems slowly to invade the ear, and rising as it proceeds, dies away in the air. This boding sound to mariners, supposed to be indicative of a storm, may be heard sometimes for two or three miles, when the bird itself is invisible, or reduced almost to a speck in the distance. The aborigines, nearly as superstitious as sailors, dislike to hear the cry of the loon, considering the bird, from its shy and extraordinary habits, as a sort of supernatural being. By the Norwegians its long-drawn howl is, with more appearance of reason, supposed to portend rain." The flesh of this bird is dark and unpalatable; but its skin, with the feathers on, is used by various barbarous tribes as an article of clothing.

Two other species, of inferior size, the red-throated diver, *C. septentrionalis*, and the black-throated, *C. arcticus*, inhabit the same regions, and are nearly similar in habits. Both these birds breed in some of the northern parts of Scotland.

The guillemots, genus URIA, have the bill of moderate length, robust, straight, compressed, and pointed; the nostrils nearly basal, lateral, linear, and partially covered by short feathers. The head is rather large and oblong, the neck short. The legs are placed far back, and their feet differ from those of the divers in wanting the hind toe. Their wings are short, narrow, and pointed; but they fly with considerable speed, and their tail is very short and rounded. These birds migrate in small flocks, and collect in vast assemblages to breed on the abrupt precipices and rocky islands of the northern seas, whence they again retire towards the end of autumn. They form no nest, but deposit their single egg, which is pyriform and of great size, on the bare rock.

The common guillemot, *Uria troile*, is somewhat less than the mallard, and has the bill longer than the head; its upper parts are black, the lower white, as are the tips of the secondary quills; in summer the head is brown, and the adult has a black stripe behind the eye. This species is very abundant along the northern coasts of Europe and America, and nowhere more so than in the British seas.

Another species, about the same size, but distinguishable by having the bill shorter and much more robust, is the thick-billed guillemot, *Uria Brunnichii*, which also occurs in the northern seas of both continents, but does not extend so far south as the former.

The Greenland dove, or little guillemot of authors, has been considered by some as constituting a distinct genus, to which Cuvier has given the name of CEPHUS. It is about the size of a large pigeon, and is entirely black, excepting a large white space on the middle of the wing, and the feet, which are red. This species, unlike those mentioned above, breeds under stones or in the crevices of rocks, where it lays two or three light-coloured eggs, spotted with dusky. It is frequent in the northern seas, and breeds on the Scottish coasts in great numbers.

2*d*. The auks,—*Alcadæ*, which form the next group, are very closely allied to the guillemots, from which they are easily distinguished by their extremely compressed and vertically elevated bill, which is usually transversely furrowed. The toes are entirely webbed, but the hind toe is wanting, as in the guillemots, which they further resemble in their habits and distribution. This tribe may be divided into several subordinate genera.

The puffins, genus FRATERCULA, have the bill shorter than the head, and as high at the base as it is long, a circumstance which gives these birds an extraordinary appearance, and has given rise to the appellations of coulternebs and parrot-bills, vulgarly applied to them. At the base of the bill there is generally an elevated fold of bare skin; and the nostrils, which are close to the margin, are mere slits. The puffins fly with rapidity, in a direct line, at the height of only a few feet over the waves; swim and dive with extreme dexterity; and nestle in the crevices of rocks, or more generally in holes formed by themselves in the turf.

The species best known and most extensively distributed is the common puffin, *Fratercula arctica*, which is of the size of a pigeon or jackdaw, with the upper parts dusky, the lower white, a broad black band round the neck, the bill red, with three grooves across each mandible. It is abundant on the northern coasts of Europe and America, where it breeds in burrows formed by itself in the soil of unfrequented islands and headlands, making no proper nest, and laying a single whitish and pyriform egg.

Another species, having a still more singular appearance, on account of two tufts of silky feathers on its head, inhabits the shores of Kamtschatka, the Kurile Isles, and others lying between Asia and America. The skins are employed by the natives as an article of clothing.

Some species having the bill less elevated, somewhat quadrangular, and notched near the tip, have been distinguished by M. Temminck under the generic name of PHALERIS. Of these may be mentioned the *Ph. psittacula*, and *Ph. cristatella*, both inhabitants of the north-western coast of America, Kamtschatka, and the Kurile Isles.

The auks properly so called, or restricted genus ALCA, have the bill more elongated, and in shape somewhat resembling the blade of a common pocket-knife, its base being feathered as far as the nostrils. As an example of the errors into which persons little conversant with living birds may fall, may be adduced the following statement of Cuvier with regard to the auks: "Their wings are decidedly too small to sustain them, and they do not fly at all." So far is this from being the case with our common species, that it flies with as much celerity as the guillemot and puffin, and in its ordinary flight outstrips the gulls and terns, although these birds fly with greater buoyancy. The statement, however, is correct as applying to the great auk, which might perhaps with propriety be referred to a separate genus.

The species so common on our coasts, as well as on those of Europe and North America, is the razor-billed auk, *Alca torda*, which is about the size of the common guillemot, and similarly coloured, being black above and white beneath, with a white band on the wing, and a line or two of the same colour on the bill.

The great auk, *Alca impennis*, is the largest bird of this family, equalling a goose in size. Its colour is similar to that of the common species; but its bill, which is marked with eight or ten grooves, is entirely black, and it has an oval white spot between the bill and the eye. Its wings are reduced to a kind of paddles, and are similar to those of the penguins, so that it does not possess the faculty of flying. It inhabits the highest latitudes of the globe, but is extremely rare, so that specimens are of very unfrequent occurrence in collections, and the only one in this country is that of the British Museum. A few instances have occurred of its being seen on the northern coasts of Scotland. In the northern seas this remarkable bird seems to represent the species of the next group, which belong to the other extremity of the globe.

3*d*. The penguins,—*Aptenodidæ*, are entirely destitute of the faculty of flying, their wings being converted into small, oblong, flattened paddles or fins, covered with mi-

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nute scale-like feathers. Their body is elliptical and depressed, their neck of moderate length, their head oblong, their bill of moderate length, generally slender and pointed, the upper mandible covered with feathers for a third of its length, or as far as the nostrils, whence a groove extends to the tip. Their legs are very short, and placed so far behind that they cannot support themselves on land, even in a vertical position, without resting on their tarsi, which are flattened behind, somewhat like the foot of a quadruped. Their life is chiefly spent on the ocean, and as they possess the faculties of swimming and diving in the highest degree of perfection, they are the most truly aquatic of all birds, and the analogues of the swallows, which are the most aërial. If any bird approaches nearly in structure and habits to a quadruped, the penguins may claim kindred with the seals, which they greatly resemble in their mode of life, going on shore merely to breed, and dragging themselves over the rocks in a similar manner.

The penguins peculiarly so named, genus APTENODYTES, as restricted, have the bill rather long, slender, and pointed, the upper mandible slightly arched towards the end, and covered with feathers at the base; the nostrils linear, with the nasal groove extending to the tip.

The Patagonian or great penguin, *Aptenodytes Patagonica* (Plate XVII., fig. 4), is nearly of the size of the great auk, of a dark-grayish blue above, white beneath, the head black, and a yellow curved band on the fore neck. It occurs in great flocks on the coasts of the Falkland Isles, New Guinea, New George, the Straits of Magellan, and other antarctic lands; feeds on fish, crustacea, and mollusca; and is employed by the natives as an article of food, although its flesh is dark-coloured and rank.

The gorfous, genus CHRYSOCOMA, have the bill short, strong, and somewhat conical, with the point a little arched. (Plate XVII., fig. 3 *b*.) The groove from the nostril ends about a third from the tip. In other respects they do not differ materially from the penguins.

The leaping gorfou, *Chrysocoma saltator*, is a handsome bird, of the size of a domestic duck, with the head and upper parts grayish black, the lower white, and the head ornamented with a large crest, of which the central part is erect and dusky, the lateral portions deflected, and of a yellow colour. It is common in the Falkland Islands and other parts of the southern seas; and, like the Patagonian penguin and other birds of this group, is said to be so stupid as to allow itself to be assailed without attempting to escape. It is extremely expert at diving; and like several birds of different families, such as the cormorants and darters, is often observed, while about to plunge beneath the surface, to leap several feet out of the water,—whence our sailors have named it the hopping penguin, or jumping Jack. The word gorfou is a corruption of goir-fugel, or gare-fowl, applied in Ferroe and the north of Scotland to the great auk, *Alca impennis*.

Several other species of this genus are known, and inhabit the same seas, such as the Papuan gorfou, *Chr. Papua;* the collared, *Chr. torquata;* the red-footed, *Chr. catarractes;* and the little gorfou, *Chr. minor*.

The sphenisques, genus SPHENISCUS, form a group characterized by their straight, compressed bill, which is irregularly grooved at the base, and has the tip of the upper mandible curved, while that of the lower is obliquely truncate, as in the cormorant. (Plate XVII., figure 3 *a*.)

The Cape sphenisque, *Spheniscus demersus*, is about twenty inches long, black above, white beneath, with the throat and cheeks black, a white line over each eye, and a black band across the fore part of the neck, and extending along each side of the body. It occurs in the vicinity of the Cape of Good Hope, where it nestles in the rocks.

Another species, *Spheniscus Magellanicus*, upwards of two feet long, with the upper parts, a band on the breast, and a collar on the middle of the neck, black, inhabits Terra del Fuego, the Straits of Magellan, and other parts of the antarctic regions, where they are very numerous. This species, like the gorfou, and probably all the birds of this tribe, has a habit of leaping several feet out of the water, either when about to dive, or when it meets with any obstacle on the surface.

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FAMILY II.—LONGIPENNÆ.

To this family belong those wandering sea-birds which, having a flight characterized by extreme buoyancy and rapidity combined, are met with on all parts of the ocean, frequently at the greatest distance from land. Their wings are always very long, although often extremely narrow; and their tail is proportionally developed. Their hind toe is small and free, or wanting; their bill pointed or hooked at the tip, but without lamellæ; their inferior larynx has only one muscle on each side; their œsophagus is wide, their stomach muscular, their cæca short. They are incapable of diving and pursuing their prey under the surface, but they swim with ease, and sit lightly and gracefully on the water. Some of them obtain their food by dipping or plunging from on wing, others by picking it up as they swim, while several wander to great distances in quest of dead animals of all kinds, and are in fact the vultures of the sea.

The petrels, *Procellariæ*, have their bill hooked at the tip, which seems as if formed of a separate piece articulated to the rest (Plate XVII., figures 5, 6, and 9); their nostrils placed close together, and enclosed by a tube which lies on the back of the upper mandible; and their hind toe reduced to a knob with a claw upon it. These birds, although many of them are very small, reside on the open ocean, where they are met with by voyagers in the most tempestuous as in the calmest weather. Their food consists of small fishes, crustacea, and especially oily substances of all kinds; and most of them when seized, whether on being wounded or on being dragged from their holes, disgorge an oleaginous matter, or squirt it through their nostrils. They are incapable of diving, and seldom swim, but are generally seen flying or gliding over the surface of the waves, mounting upon their ridges and descending into the hollows, often so close as to seem walking on the water. Hence the name Petrel, or Little Peter, bestowed upon them, in allusion to St Peter's progress on the waves. In stormy weather they frequently fly in the wake of a ship, to shelter themselves from the wind. On account of this habit they are held in aversion by sailors, who, imagining them to be predictive of tempests, and in league with the mysterious source of evil, bestow on them the opprobrious appellation of Mother Carey's chickens. Their flight is rapid and buoyant; they breed in holes and crevices of the rocky coasts; and are more numerous in the antarctic than in the northern seas.

Those which have the lower mandible truncate are more peculiarly named petrels, genus PROCELLARIA.

Of these the largest is the giant petrel, *Procellaria gigantea*, which has a length of about three feet and a half, and is of a dusky colour above, whitish beneath, with the bill and legs yellow. It is of frequent occurrence in the southern seas, is observed to be most lively in stormy weather, and feeds on fishes, and the carcasses of seals, birds, and other animals.

The pintado, or Cape petrel, *Procellaria Capensis*, is about fourteen inches long, variegated with brown and white, and occurs in large flocks in the antarctic seas, particularly in the vicinity of the Cape of Good Hope. Like most of the other species, it flies very low, feeds on fish

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and the carcasses of cetaceous animals, and when caught squirts out a quantity of oil from the nostrils.

In the arctic seas a very abundant species is the fulmar petrel, *Procellaria glacialis*, which is nearly of the size of the herring gull, and has the upper parts of a light bluish-gray, the head and lower parts white. It is extremely voracious, and although its principal food consists of fish, it devours indiscriminately any floating animal substance, and follows in flocks the track of a wounded whale, until the huge animal is exhausted, when it alights on the carcass, and devours the blubber until satiated. This bird is one of those most familiar to the sailors of the whale-ships, on which it constantly attends, to pick up any offal that is thrown overboard, and come in for its share of the plunder when a whale has been captured. It breeds abundantly in the island of St Kilda, the inhabitants of which obtain a large quantity of oil from the stomachs of the individuals which they catch for that purpose.

Of the smaller dark-coloured species may be mentioned the common or storm petrel, *P. pelagica*, which is not larger than a lark, and in its flight resembles a swallow (Plate XVII., figure 5); Leach's petrel, *P. Leachii;* and Wilson's petrel, *P. Wilsonii*. Respecting the latter, we may quote the following passage from the description given of it by M. Audubon, in his *Ornithological Biography*. "But now, ever flapping its winglets, I have marked the little bird, dusky all over save a single spot, the whiteness of which contrasts with the dark hue of the waters, and the deep tone of the clear sky. Full of life and joy, it moves to and fro, advances towards the ship, then shoots far away, gambols over the swelling waves, dives into their hollows, and twitters with delight as it perceives an object that will alleviate its hunger. Never fatigued, the tiny petrels seldom alight, although at times their frail legs and feet seem to touch the crest of the foaming wave. I love to give every creature all the pleasure I can confer upon it, and towards the little things I cast over the stern such objects as I know they will most prize. Social creatures! would that all were as innocent as you! There are no bickerings, no jealousies, among you; the first that comes is first served: it is all the result of chance; and thus you pass your lives. But the clouds gather, the gale approaches, and our gallant bark is trimmed. Darkness spreads over the heavens, and the deep waters send back a blacker gloom, broken at intervals by the glimmer of the spray. You meet the blast, and your little wings bear you up against it for a while; but you cannot encounter the full force of the tempest; and now you have all come close beneath me, where you glide over the curling eddies caused by the motion of the rudder. You shall have all possible attention paid you, and I will crawl to the camboose, in search of food to support your tiny frames in this hour of need. But at length night closes around, and I bid you farewell....The gale is over; the clear blue of the sky looks clearer than ever, the sun's rays are brighter, on the quiet waters the ship seems to settle in repose, and her wings, though widely spread, no longer swell with the breeze. At a distance around us the dusky wanderers are enjoying the bright morning; the rudder-fish, yesterday so lively, has ended its career, so violently was it beaten by the waves against the vessel; and now the petrels gather around it, as it floats on the surface. Various other matter they find; here a small crab, there the fragments of a sea-plant. Low over the deep they range, and now with little steps run on the waters. Few are their notes, but great their pleasure, at this moment. It is needless for me to feed them now, and therefore I will return to my task."

The puffin-petrels, genus PUFFINUS, are separated from the rest on account of their having the extremity of the lower mandible decurved as well as that of the upper, and the nostrils opening, not by a common orifice, but by two distinct apertures. (Plate XVII., fig. 9.)

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Of this genus may be mentioned the cinerous puffin-petrel, *Puffinus cinereus;* the Manks petrel, *Pr. anglorum;* and the dusky petrel, *Pr. obscura*.

In the genus HALADROMA of Illiger, the throat is dilatable like that of the cormorants, and the hind toe is entirely wanting as in the albatrosses. In the genus PACHYPTILA of the same author, the bill is enlarged at the base, and its margins are garnished interiorly with fine delicately-pointed vertical lamellæ. (See plate XVII., fig. 6.)

The albatrosses, genus DIOMEDEA, are the largest and most powerful of all the feathered wanderers of the ocean. Their bill, which is large, strong, and sharp-edged, is terminated by a strong hook; their nostrils, which are tubular, are placed apart; and their feet are destitute of the hind toe. Their plumage is full, soft, and elastic, and their wings, although narrow, are exceedingly long. They are thus equally organized for swimming and flying, and are met with in all parts of the intra-tropical and southern oceans, sometimes following a ship in full sail for many days, to pick up the refuse thrown overboard. They fly with surprising buoyancy and speed, and are able to bear up against the most violent tempests. When fatigued or satiated they rest upon the waters. Their food consists of the carcasses of all sorts of animals, as well as live fishes, crustacea, mollusca, and other creatures, and their voracity is such that sometimes having gorged themselves to excess, they are unable for a time to fly, and may be caught or destroyed. Under these circumstances, however, birds generally disgorge the contents of their gullet and stomach, and by thus lightening themselves, are enabled to escape.

Of the different species of this genus, that which is the best known, as well as the largest, is the wandering albatross, *Diomedea exulans*. It is as large as a swan, being four feet in length, and measuring ten feet between the tips of its extended wings; its upper parts dusky, the lower white, the neck and sides transversely streaked with brown, the primary quills black, the bill yellowish white, the feet flesh-colour. This celebrated bird is principally met with in the seas adjacent to the Cape of Good Hope, and in those that separate the American continent from the Asiatic. It is extremely voracious, feeding on fishes, mollusca, and the carcasses of whales and other animals It is said that when it cannot swallow a large fish at once, it introduces part of it, and waits until it is digested before swallowing the rest. Its flesh, although hard and dry, is eaten by the inhabitants of Kamtschatka, who use its bones for tobacco-pipes and needle-cases.

From the albatrosses to the larger birds of the next genus the transition is but slight, both as regards form and habits.

The gulls, genus LARUS, Plate XVII. fig. 8, constitute an extensive group, of which representatives are found in all parts of the globe. They are characterized by their longish, compressed bill, of which the upper mandible is arched towards the end, while the lower is there furnished with an angular prominence. The nostrils, which are placed near the middle, are linear-oblong and pervious. Their body is generally light, the neck of moderate length, their head ovate and rather large, their legs of ordinary length, and their hind toe very small, or sometimes obsolete. Some of the species are met with in the open ocean, but it is chiefly along the coasts, and especially near the mouths of rivers, that they are most frequently seen, and in stormy weather they often make incursions over the land in search of worms, larvæ, and carrion. Their food consists chiefly of small fishes, crustacea, and mollusca; but to the larger species hardly

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any animal substance comes amiss. They breed along the shores, on unfrequented islands and headlands, laying in a hollow on the ground from two to four eggs, spotted with dusky.

Among the larger species, some are remarkable for the dark or blackish hue of their back and wings; but in general the colour of those parts is a light-grayish blue, while that of the lower is pure white. One species, the ivory gull, *Larus eburneus*, has the plumage entirely of the latter colour when in the adult state. The greater black-backed gull, *Larus marinus*, the smaller black-backed gull, *Larus fuscus*, and the thick-billed gull of New Holland, *Larus melanoleucos*, afford examples of the first kind above alluded to. The largest known species is the burgomaster, *Larus glaucus*, of a light-grayish blue above, white beneath, with the tail and tips of the wings also white. It inhabits the arctic regions of Europe and America, seldom making its appearance in the temperate climates. One of the most common species on our coasts is the herring gull, *Larus argentatus*, which remains with us throughout the year. A gradual transition is observable from these larger species, which assimilate to the albatrosses, to the smaller, which are intimately connected with the terns.

Some species having very peculiar characters, have been separated from the gulls, and formed into a genus apart. These are the jagers, genus LESTRIS, which have the tip of the upper mandible hooked, and the nostrils larger and placed nearer the end of the bill than those of the gulls. Their tail is generally pointed, their wings long, and their flight is extremely rapid. Although they occasionally fish for themselves, they obtain their food chiefly by attacking various species of gulls and terns, which they teaze to make them disgorge their food, which they then swallow.

Of this genus the more remarkable species are the skua, *Lestris catarractes*, which is nearly equal in size to the great black-backed gull; the pomarine jager, *L. pomarinus;* and Richardson's jager, *L. Richardsonii*, which is common on our coasts in autumn, and breeds in the Shetland Islands and Hebrides.

The terns, genus STERNA, are generally of small size, and remarkable for their slender body, long and narrow wings, and forked tail. Their feet are extremely short, and their bill longish, compressed, and pointed. They very seldom swim, but, when fatigued or satiated with food, repose on the rocks or sands. Their flight is extremely buoyant, and they usually obtain their food by plunging after it into the water from on wing. From their form and the peculiar mode of flying, they have also obtained the name of sea-swallows.

The most common species on the coasts of Europe are the arctic tern, *Sterna arctica;* the common tern, *St. Hirundo;* and the little tern, *St. minuta;* but several other species occur there.

The noddies, genus ANOUS, differ from the terns in having the tail even at the end, and nearly equal with the wings. Their bill also is more like that of the smaller gulls. They are said to be so stupid as to allow themselves to be killed without attempting to fly off; but this only happens in places where they have not been accustomed to meet with man.

The species best known is the black noddy, *Anous niger* (*Sterna stolida*, Linn.), which is very common in the tropical seas, and is of a sooty-brown, excepting the top of the head, which is grayish white. It often settles on the rigging of vessels, when the sailors sometimes catch it at night while asleep.

The skimmers, genus RHYNCHOPS, (Plate XVII., fig. 7), are very nearly allied to the terns, but are distinguished from all other birds by the extraordinary form of their bill, of which the upper mandible is considerably shorter than the lower, and grooved beneath, so as to receive the edge of the latter, which is extremely thin. They procure their food in the same manner as the terns, skimming along the surface of the water, and dipping their bill into it to seize a small fish, as opportunity occurs.

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The only species whose habits are known is the black skimmer, *Rhynchops nigra*, which is about twenty inches long, its bill and feet red, its upper parts black, the lower white, its wings considerably longer than the tail. It occurs along the coasts of America, from New York to Brazil, breeding on the sandy shores in June, and continuing in flocks all the year.

FAMILY III.—TOTIPALMÆ.

The birds of which this family is composed are those to which the epithet *palmipede* is more peculiarly applicable; for not only are their anterior toes connected by webs or membranes, as in the other tribes, but their hind toe is similarly connected with the inner. Their tarsi are generally short, their wings and tail long, their neck elongated, and their bill rather slender, somewhat conical, but generally hooked at the joint. They swim, and for the most part dive, with admirable dexterity, generally fly with great celerity, feed entirely on fishes and other marine animals, and are remarkable among web-footed birds for frequently perching on trees.

The pelicans, *Pelecani*, comprehend those which have at the base of the bill a space destitute of feathers. The skin of their throat is extensile, their tongue very small, their gullet of great width, their cæca small, their nostrils mere slits, sometimes obsolete.

The pelicans properly so called, genus PELECANUS, Plate XVII., fig. 10, are distinguished from all other birds by the singular structure of their bill, of which the upper mandible, however, presents nothing very remarkable, while the lower has its rami extremely slender and elastic, with a large dilatable membranous bag attached to it. They are birds of large size, with wings of moderate length, the tail rounded, the feet short, and the claws curved.

The most remarkable species is the common pelican, *Pelecanus onocrotalus* (above referred to), which is as large as a swan, and entirely of a white colour tinged with red, excepting the alula and primary quills, which are black. Its length is nearly six feet, and its extended wings measure about fifteen. Its upper mandible is flattened, with a hook at the point; and the sac appended to the lower mandible extends about nine inches down the neck, and may be dilated so as to hold a man's head with ease. This pelican occurs in the tropical and warmer temperate regions of the old continent, and is common in the eastern countries of Europe. Its principal food is fish, which it catches with great dexterity, by plunging after it from on wing. In fishing it fills the gular pouch, and does not immediately devour its prey, but when it has obtained a sufficiency, returns to the shore, and swallows it at leisure. The female forms a large nest of grass in a marshy place, and lays two or three white eggs, similar to those of a swan.

The brown pelican, *P. fuscus*, of a grayish-brown colour, and nearly four feet in length, is common in most parts of America, and especially in the West Indies. A very large species, *P. australis*, of a white colour, with the upper part of the back, the quills, and tail, black, inhabits New Holland.

The cormorants, genus PHALACROCORAX, resemble the pelicans in their general form, but are destitute of the large gular sac, having merely a bare dilatable membrane at the base of the lower mandible. They differ farther in not procuring their prey by plunging after it from

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on wing, their mode of fishing being similar to that of the divers.

The common cormorant, *Phalacrocorax carbo*, is nearly as large as a goose, and has a brownish-black colour, with a white spot on the thigh, and streaks of the same colour on the head and neck. It nestles in the cavities of rocks, or on trees, laying three pale-green eggs, crusted with white calcareous matter; and is common in the northern parts of both continents. It is stated that this species was formerly trained in England for the purpose of catching fish. "When they come to the rivers," says Willughby, "they take off their hoods, and having tied a leather thong round the lower part of their necks, that they may not swallow down the fish they catch, they throw them into the river. They presently dive under water, and there for a time, with wonderful swiftness, they pursue the fish, and when they have caught them, they rise presently to the top of the water, and pressing the fish lightly with their bills, they swallow them, till each bird hath in this manner swallowed five or six fishes; then their keepers call them to the fist, to which they readily fly, and, little by little, one after another, vomit up all their fish, a little bruised with the nip they gave them in their bills. When they have done fishing, getting the birds on some high place, they loose the string from their neck, leaving the passage to the stomach free and open; and for their reward they throw them part of the prey they have caught, to each, perchance, one or two fishes, which they by the way, as they are falling in the air, will catch most dexterously in their mouths."

A very common species on our coasts is the crested cormorant, *Phal. cristatus*, which is of a dark-greenish colour, with a recurved frontal tuft, and resembles the preceding in its habits, breeding in the rocky caverns of islands and headlands. Many other species occur in different parts of the world, the genus being generally distributed.

The frigate-birds, genus Tachypetes, differ from the cormorants in having the tail forked, the wings extremely elongated, the feet very short, with their webs emarginate, and the tip of both mandibles decurved. Their flight is extremely rapid and buoyant, and they prey upon fishes, which they capture by plunging after them from on wing, or obtain by forcing the gannets to disgorge. Only one species is well known.

The common frigate-bird, *Tachypetes aquilus*, is of a dusky colour, more or less variegated with white on the neck, and sometimes measures ten feet between the tips of its extended wings. It inhabits the tropical regions, and is found in great abundance on the island of Ascension. Its principal food consists of flying-fishes, which it captures during their aërial excursions. The following account of this remarkable species, generally known to navigators by the name of the man-of-war, or frigate, is given by Mr Audubon. "This bird is possessed of a power of flight, which I conceive superior to that of perhaps any other bird. However swiftly the Cayenne tern, the smaller gulls, or the jager, move on wing, it seems a matter of mere sport to it to overtake any of them. The goshawk, the peregrine, and the gyr-falcon, which I conceive to be the swiftest of our hawks, are obliged to pursue their victim, should it be a green-winged teal or passenger-pigeon, at times for half a mile, at the highest pitch of their speed, before they can secure them. The bird of which I speak comes from on high with the velocity of a meteor, and on nearing the object of its pursuit, which its keen eye has spied while fishing at a distance, darts on either side to cut off all retreat, and with open bill forces it to drop or disgorge the fish which it had just caught. See him now! yonder, over the waves leaps the brilliant dolphin, as he pursues the flying-fishes, which he expects to seize the moment they drop into the water. The frigate-bird, who has marked them, closes his wings, dives towards them, and now ascending, holds one of the tiny things across its bill. Already fifty yards above the sea, he spies a porpoise in full chase, launches towards the spot, and in passing seizes the mullet that has escaped from its dreaded foe; but now, having obtained a fish too large for his gullet, he rises, munching it all the while, as if bound for the skies. Three or four of his own tribe have watched him, and observed his success. They shoot towards him on broadly extended pinions, rise in wide circles, smoothly, yet as swiftly as himself. They are now all at the same height, and each, as it overtakes him, lashes him with its wings, and tugs at his prey. See! one has fairly robbed him, but before he can secure the contested fish it drops. One of the other birds has caught it, but he is pursued by all. From bill to bill, and through the air, rapidly falls the fish, until it drops on the waters, and sinks into the deep. Whatever disappointment the hungry birds feel, they seem to deserve it all."[1]

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The boobies, or gannets, genus Sula, have the bill straight, conical, a little compressed, and with the point somewhat deflected, the edges serrate, or cut into by short parallel lines. The throat and the space around the eyes are bare; the claw of the middle toe serrate, the wings long and very narrow, and the tail cuneate or tapering. They hover over the water when fishing, and plunge headlong after their prey, resting a few moments on emerging before they resume their flight.

The common gannet or solan goose, *Sula bassana*, occurs on the coasts of Europe and North America, and breeds in vast numbers on remote and rocky islands. The Bass Rock at the entrance of the Frith of Forth is a well-known haunt of this species, as are Ailsa Craig in the Clyde, St Kilda, and Suliskerry. The nest is very bulky, and composed of sea-weeds; the single egg not larger than that of a domestic duck, and of a white colour; the young, at first covered with snow-white down, is when fledged of a dark-brown colour, spotted with white. Although the flesh of this species is rank and oily, it was formerly considered a kind of delicacy, and is still sparingly used in the south of Scotland.

The booby gannet, *Sula candida*, is inferior in size to the species just mentioned, which it closely resembles in form and habits. It is common on the coasts of the warmer parts of America, particularly in the Bahama Islands and the Brazilian seas. Although it sometimes nestles on the ground, it generally builds on trees, and reposes there at night. It is said to be a very stupid bird, allowing itself to be knocked on the head or seized, without attempting to escape,—whence the name of booby, commonly given to it by the sailors, who frequently employ it as an article of food, although its flesh is dark-coloured and disagreeable.

The darters, genus Plotus, resemble the cormorants in the form of their body and feet, but are more slender, and have a very elongated neck, with a small head, and a straight, slender, and pointed bill. Like the cormorants, they swim deep in the water, but with agility, and in diving spring fairly out of it to plunge headlong after their prey. They inhabit the warm countries of America.

The black-bellied darter, *Plotus melanogaster*, Plate XVIII., figure 1, is upwards of three feet long, of a dusky colour, with the neck and back streaked with white. The white-bellied darter, *P. anhinga*, is about the same size, but has the lower parts white. It inhabits Brazil and

[1] *Ornithological Biography.*

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other parts of America, roosting at night on trees, whence, should one approach, they drop into the water as if dead; and on emerging at a distance, show only their long slender necks and heads, which bear so much resemblance to those of serpents, that this species is frequently named the snake-bird.

The tropic birds, genus PHAETON, which form the last group of this section, bear a considerable resemblance to the gannets, but are readily distinguished by the two extremely elongated feathers of their tail, on account of which the French give them the not inappropriate name of *paille-en-queue*. Their head is entirely feathered; their bill straightish, tapering, pointed, and denticulated on the edges; their feet are short, and their wings long. The flight of these birds is rapid and buoyant, and they are often seen far out at sea. As they seldom extend their range beyond the tropics, their occurrence apprises navigators of their entrance into the warmer regions. They perch and nestle upon trees.

Two species are distinguished;—the common, or white-tailed tropic bird, *Phaeton æthereus;* and the red-tailed species, *Ph. phœnicurus*. The former is white, with the ocular region and shoulders black, the primary quills of the same colour, and the bill red. It inhabits the Atlantic Ocean. The latter is of a pale rose-colour, or reddish white, with the ocular region and wing-coverts deep black, and the two elongated feathers of the tail red. It occurs in the Indian and African Seas, at Madagascar, the Cape of Good Hope, the Isle of France, and many of the South Sea islands.

FAMILY IV.—LAMELLIROSTRES.

The birds of this family are readily distinguished from those of the preceding by the peculiar structure of the bill, which has its margins furnished with horny lamellæ, or dentiform processes, and its surface covered with soft skin, in place of the horny envelope which is spread over that of the other Palmipedes. The tongue, which is broad and fleshy, has its margins also lamellate; the gizzard is extremely muscular, although not of large capacity, and the cæca are rather long. Another remarkable distinction is found in the lower larynx, which generally has a very extraordinary dilatation in the males. Their body is usually somewhat depressed, their wings of moderate length, their feet short, and their neck more or less elongated, sometimes of extreme length. They swim with ease, but walk in a constrained and vacillating manner; and are for the most part phytophagous, though many feed on mollusca, crustacea, and fishes. They occur in all parts of the globe,—some being maritime, but the greater number lacustrine or fluviatile, that is, frequenting lakes or rivers. They are naturally arranged into two groups;—the one (*Anatidæ*) comprising the swans, geese, and ducks; the other (*Mergidæ*) composed of the mergansers.

The great group of *Anatidæ* includes all those web-footed birds which have their bill large and broad, covered with a thin membrane, and having its edges furnished with transverse or oblique lamellæ, the object of which seems to be to allow the water to escape when the bird has seized its food. Vegetable substances, especially seeds, roots, and blades of grasses, form the principal nourishment of many of the species; but others feed on fishes, mollusca, insects, and worms. The piscivorous species dive in pursuit of their prey, while those which feed on vegetable matter either procure it on shore, or along the margins of the water, or, while floating on the surface, obtain it from some depth by means of their long neck. The flesh of many of these birds is much esteemed, but is not so readily digestible as that of the waders and gallinaceous order. Many of them moult twice in the year, and after the summer change the males assume in part the colours peculiar to the females, which, on the contrary, exhibit no variation. They generally breed in marshy places, and deposit numerous eggs. The young, which are at first covered with stiffish down, are capable of walking and swimming immediately after birth.

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The characters by which the subdivisions of this group are distinguished are derived chiefly from the form of the bill. In the swan that organ is as broad at its fore part as at the base, where its height is greater than its breadth, and the nostrils are placed about the middle. In the geese, the bill is shorter than the head, higher than broad at the base, and narrower towards the end. Lastly, in the ducks properly so called, the bill is at least as broad at its extremity as at the base, where it is broader than high the nostrils are placed on the back of the bill near the base. In the swans the neck is extremely long, in the geese of moderate length, and in the ducks generally rather short.

The *swans*, genus CYGNUS, are the largest birds of the family, and are characterized by the elegance of their form, and the graceful ease with which they glide over the surface of the water, although on land their motions are more constrained. Their body is large, their neck extremely elongated, their head oblong, their wings large, and their feet short and strong. They live chiefly on the seeds and roots of aquatic plants, and nestle among the reeds by the margins of lakes and rivers. They are strictly monogamous, and the young swim and walk immediately after exclusion.

The wild swan, *Cygnus ferus*, has the bill yellow at the base, and black towards the end, the plumage pure white, but in the young of a gray colour. It is readily distinguished from the domestic swan by having the base of the bill flattened above, and by the curvature formed by the wind-pipe, which enters into a cavity in the crest of the sternum, from which it is reflected anteriorly, and then passes into the thorax. This species inhabits the northern regions of both continents, whence it migrates southward on the approach of winter, remaining in the temperate countries until the return of spring. The female lays from five to seven or eight eggs, of a whitish colour tinged with olive, and is said to incubate six weeks. The flesh and eggs are highly esteemed, and the skins are prepared with the down to be made into garments. The down itself forms an article of commerce, which is in considerable demand in the colder countries of Europe. The song of the swan is familiar to all the lovers of poetry; but, like many equally accredited facts, has no real existence; for the cry of this bird, although clear and shrill, is never modulated into harmony. When heard at a distance, however, especially from a flock on wing, it is extremely pleasing. Another fable regarding the vast strength of wing of this bird was long believed,—a blow from it being alleged as sufficient to break a man's thigh. "It is high time," says Montagu, "such absurdities should be erased in this philosophic age, and that the mind of man should reason before he continues to relate such accounts, only calculated to frighten children. Let the bones of the wing of the swan be examined, and compared with the thigh of a man, or even of his arm, and it will be evident that it would be as impossible for a swan to break a man's arm, as it would be to break his head with a reed. The bone of a man's arm would bear a pressure fifty times as great as the bone of a swan's wing; how, then, is the inferior in size and strength to break the superior, without at least being itself fractured? It should also be recollected, that a bird is incapable of striking with any degree of force while all its quill-feathers are perfect, the resistance of the air against such a surface being too great to allow of

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its moving with sufficient velocity to inflict any sensible pain."[1]

A species very nearly allied to the above is Bewick's swan, *Cygnus Bewickii*, which was first distinguished as a species by Mr Yarrell and Mr Richard Wingate of Newcastle. It has the bill black, with its base orange yellow, the plumage white, and the tail of eighteen feathers, whereas there are twenty in that of the common wild swan. The curvature of the trachea is also different, and the size of the species is about a third smaller. It inhabits the arctic regions of both continents, migrating southward in winter.

The mute or tame swan, *Cygnus olor*, has the bill red, its edges, the nail at its tip, and a large knob at the base of the upper mandible, black; the plumage white, the tail of twenty-four feathers. In this species the trachea has no extra thoracic curvature. The tame swan is said to be found in its wild state in the eastern countries of Europe and Asia. It is generally distributed over Europe in a domesticated state, forming a great ornament to our rivers and artificial pieces of water. It makes its nest of grass, among reeds, and deposits seven or eight eggs of a greenish-white colour, which are hatched in seven or eight weeks. The young are of a gray colour, and were formerly much esteemed as an article of food.

The black swan, *Cygnus atratus*, of which the general colour of the plumage is brownish black, with part of the wings white, and the bill red, inhabits various parts of New Holland, and is now not uncommon in a domesticated state in this country. (See Plate XVIII., figure 5.)

Intermediate between the swans and geese are several species, such as the Guinea goose, *Anas cygnoides* of Linnæus, and the spur-winged or Gambia goose, *Anas Gambensis* of the same author,—which, although less elegant than the swans, are yet nearly allied to them in the form of their bill.

The *geese*, genus Anser, are distinguished, as has been already said, by the form of their bill, which is short, and narrowed towards the point. Their feet are also proportionally longer than those of the ducks, so that they have a greater facility in walking. They swim less, however, and are incapable of diving. They live in flocks, feed on gramineous plants and seeds, migrate in large bodies, which during their flight are usually disposed in divergent lines, and breed in marshy places, laying numerous eggs. Those species which have the bill more slender and somewhat cylindrical, are separated by some authors to form the genus Bernicla. Three species of geese properly so called, and two of bernicles, are not uncommon during winter in this and other countries of Europe.

That to which the origin of the domestic goose is attributed, the gray lag, or common wild goose, *Anser ferus*, is nearly three feet long, with the bill large and of an orange colour, the feet flesh-coloured, and the plumage light gray and clove brown; the rump and lower parts white. It was formerly very abundant in this country, where it resided all the year, but is now met with only in small flocks in the winter season, although a few individuals have recently been found to breed in the north of Scotland—for example, in the islets of the lochs of Sutherland.

The bean goose, *Anser segetum*, is a little smaller, with the bill more elongated, and of an orange colour, with its base and the nail black; the upper part ash-gray tinged with brown, the rump dark brown, the abdomen and lower tail-coverts white. This species is much more plentiful with us than the last, appearing in large flocks in November, and retiring northward in April and May.

The white-fronted goose, *Anser albifrons*, has the bill and legs orange, the plumage gray on the upper parts, on the lower white, and a patch of the same colour on the forehead.

The common bernicle, *Anser leucopsis*, which has the forehead, cheeks, and throat white, with the crown of the head, the neck, and the breast black, is not unfrequent on the western coast of Britain in winter; and the brent goose, *Anser torquatus*, characterized by having the head, neck, and breast black, with a white patch on each side of the neck, is also common in many parts, especially along our eastern shores. The former of these species was long believed, even by the learned, to be the produce of a species of cirripodous animal, the *Lepas anatifera* of Linnæus, the long feather-like branchiæ of which gave rise to this absurd fable.

Another species of bernicle was observed, on Captain Parry's second voyage, on Melville Peninsula, and named by Dr Richardson, in the *Fauna Boreali-Americana*, in honour of Mr Hutchins, from whom Pennant and Latham derived most of their information respecting the birds of Hudson's Bay. It is about twenty-five inches in length, with a very short black bill; the head, neck, rump, and tail pitch-black, and a white kidney-shaped patch upon the throat.

From the bernicles and geese some authors distinguish, under the generic name of spurwing, Chenalopex, the species usually named the Egyptian goose, which has the bill longer than the bernicles, and has the wings armed with a spur upon the bend. It inhabits various parts of Africa, especially Egypt and the Cape of Good Hope, whence it has been introduced into this country.

The next genus, Cereopsis, is formed by a New Holland species, resembling the bernicles in form, but with the bill smaller, and having at its base a membrane extending over the forehead. The palmation of the feet is not so full as usual.[2] (Plate XVIII., figure 2.)

The *ducks*, properly so called, have the legs much shorter than the geese, and placed farther back, the neck shorter, and the body more depressed. Their trachea also has a large dilatation at its bifurcation.

Some of them, having the hind toe margined with a membrane or lobe, the tarsi more compressed, the head larger, and the wings shorter, feed on fishes and other aquatic animals, and are less expert at walking, but dive with greater agility. These species have been variously grouped by authors into numerous genera, of which the following are among the more remarkable.

The *scoters*, genus Oidemia, have the bill short and broad, with an elevated tumour or knob at the base, but towards the tip much depressed and flattened, the nail obtuse and roundish; the lamellæ widely set, and scarcely projecting; the nostrils oval and sub-medial, the tail short and graduated.

To this genus belong the velvet scoter, *Oidemia fusca*; the black scoter, *O. nigra*; and the surf scoter, *O. perspicillata*; which occur along the coasts of the northern temperate regions in winter, feeding on fishes, and especially mussels and other testaceous mollusca. Like that of the other sea-ducks, their flesh is held in little estimation, being dark-coloured and tough, with a fishy flavour.

The *garrots*, genus Clangula, have the bill shorte than the head, elevated at the base, narrowed towards the end; the lamellæ numerous, but not projecting; the nostrils roundish, and medial; the tail of moderate length, and graduated.

The golden-eye, *Clangula chrysophthalma*, which is white, with the head, the back, and the tail black, a small

[1] *Ornithological Dictionary.*

[2] For the history of the only known species, *Cer. Novæ Hollandiæ*, see *Zoological Gardens*, vol. ii. p. 315.

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spot before the eye, and two bands on the wing, white, breeds in the arctic regions of both continents, and appears on the estuaries and lakes of the more temperate countries in winter. The female is of a gray colour, with the head brown.

To this genus belongs the harlequin-duck, *Clangula histrionica* (Plate XVIII., fig. 3, which is distinguished by having a large patch of white on the lore, a spot on the ear, a longitudinal band on the sides of the neck, a transverse band on the neck, and another on each side of the breast, white; with the speculum or wing-spot blue, and the legs dusky. It derives its name from the singularity of its markings, and inhabits the northern parts of both continents.

The *pochards*, genus FULIGULA, have the bill as long as the head, broad and much depressed anteriorly, and a little dilated towards the tip; the upper lamellæ not projecting beyond the margin; the nostrils oblong, sub-basal; the wings and tail short, the latter rounded. This section contains a great number of species, most of which are maritime and piscivorous, although the flesh of many is considered palatable, and that of one, the canvass-backed duck, has been celebrated by the epicures of the western world.

The red-headed pochard, *Fuligula ferina*, of which the head and neck are bright chesnut, the breast black, the sides and scapulars marked with undulated lines of black and grayish white, is not uncommon on the coasts of Europe during the winter, and is not unfrequently seen in our markets.

Another common species is the scaup-pochard, *Fuligula marila*, which has the head and neck black glossed with green, the back and scapulars whitish with undulating black lines, and the alar speculum white.

The canvass-backed pochard just alluded to, *Fuligula valisneria* (Plate XVIII., figure 4), resembles the red-headed species, and is characterized by having the forehead and cheeks dull brown; the head and upper part of the neck fulvous, the lower part with a black belt; the back, scapulars, and belly white, marked with narrow black lines. These birds arrive in the United States from the arctic regions about the middle of October, and frequent the large rivers and lakes, where they feed chiefly on the roots of a grass-like plant, the *Valisneria spiralis*. Although extremely shy, vast numbers of them are killed on account of the delicacy of their flesh. Towards evening they collect into large flocks, so extensive as sometimes to cover several acres, and, when rising simultaneously on wing, to produce a noise like thunder.

The *eiders*, genus SOMATERIA, have the bill more elongated than that of the garrots, tumid and elevated at the base, and extending over the forehead in the form of two narrow processes; the lamellæ large and distant; the nostrils small, oval, and medial; the wings and tail short. The males are distinguished by their greater size and superior beauty. Only two species of this genus are known, both inhabiting the northern and temperate regions of Europe and America.

The common or St Cuthbert's eider, *Somateria mollissima*, is characterized by having the bill furnished at its base with lateral prolongations, in the form of two narrow flat lamellæ. The male has the lower parts black, the upper parts and the neck white, the top of the head violet-black, and the cheeks pale green. The female has the whole plumage reddish brown, with transverse black bars. This species is extremely abundant in Iceland, Lapland, Greenland, Spitzbergen, and the countries bordering on Hudson's and Baffin's Bays; but it is also common in all the northern parts of Europe and America. The female lays five or six pale greenish-gray eggs, and lines her nest, which is composed of sea-weeds and other maritime plants, with the fine and elastic gray down, which she plucks from her breast for that purpose. This down is carefully collected in northern countries,—each nest being generally robbed twice in the season. One female is stated to yield half a pound of down, which, however, is reduced to one half by being cleaned. It is extremely soft and warm, and so elastic that two handfuls are sufficient to fill a quilt five feet square. In 1750, the Iceland Company at Copenhagen sold so much of this article as produced 3747 rix-dollars, in addition to what was sent directly to Gluckstadt. Besides supplying this valuable down, the eiders afford an esteemed article of food to the Greenlanders, who moreover convert their skins into warm and comfortable under garments. Although the species occurs in Britain, it is nowhere so plentiful as to afford enough of down to render it available as an article of commerce.

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The king-eider, *Somateria spectabilis*, which has the lateral prolongations at the base of the bill in the form of two elevated, compressed tubercles, is very similar to the other species, and inhabits the same countries, breeding in the same manner, and lining its nest with down of equal quality, plucked from its own plumage. The skins are formed into winter garments by the inhabitants of Siberia and Kamtschatka; but as this species is not so numerous as the other, its down is not of equal importance in a commercial point of view.

Other groups of ducks have the hind toe not bordered by any membrane, the head smaller, the feet narrower, the neck longer, the bill less tapering, and the body more slender. They feed chiefly on vegetable substances, although they also devour fishes, insects, worms, and mollusca. In this section, likewise, various generic divisions have been made.

The *shovellers*, genus RHYNCHASPIS, have the bill longer than the head, with the upper mandible semi-cylindrical, and enlarged at the end, and the lamellæ so long and slender as to resemble filaments.

The common shoveller, *Rhynchaspis clypeata*, inhabits various parts of the north of Europe and America, and is sometimes met with in England. It is about twenty inches in length, with the head and neck glossy-green, the back brown, the breast and abdomen brownish red, and the smaller wing-coverts pale blue.

Another species, the fasciated shoveller, *Rhynchaspis fasciata*, of a rusty-brown colour, transversely striped with white beneath, and having the tip of the bill membranaceous, is a native of New South Wales.

The *shieldducks*, genus TADORNA, have the bill tumid and elevated at the base, where there is a small tubercle, but much flattened towards the point; the lamellæ short and distant; the nostrils oval and medial.

The common shieldrake, *Tadorna Bellonii*, which is one of the most beautiful species of this family, is not very uncommon in some parts of Britain, and occurs also on the coasts of the northern and western countries of Europe. It is characterized by having the head and upper part of the neck greenish black; the back, wing-coverts, and flanks white; the scapulars black, and a broad band on the breast ferruginous. The female nestles in a rabbit-burrow, or other hole in the sandy pastures on the sea-shore, generally forming her nest of down plucked from her breast, and laying from eight to twelve white eggs. Instances have occurred of its breeding with the common duck; and Montagu states that it bears confinement well, appearing to enjoy perfect health, provided access to a pond is allowed it.

The *musk-ducks*, genus CAIRINA, have the bill also furnished with an elevated tubercle at the base; the edges of the mandibles sinuated; the face and lores covered with a bare tuberculated skin; and the wings furnished with a knob or spur at the bend.

The common musk-duck, *Cairina moschata*, which is now generally distributed over Europe in a domesticated

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state, is a native of the warmer parts of America. In its natural state it has the plumage entirely of a black colour, glossed with green and blue, excepting the wing-coverts, which are white.

The *pintails*, genus DAFILA, have the bill destitute of tubercle at the base, narrow, somewhat cylindrical, with its edges dentato-laminate; the nostrils are basal, and the tail elongated, and tapering to a point.

The common pintail, *Dafila acuta*, has the head umber-brown, with a longitudinal white line on each side of the occiput and hind neck; the back and flanks undulated with black and grayish white; the lower parts white; and the two central tail-feathers black. It breeds in the arctic regions of Europe, Asia, and America; retires southward in winter; is very shy and vigilant; and is much esteemed as an article of food.

The ducks, strictly so called, genus ANAS, are distinguished by having the bill simple at the base, as long as the head, depressed, broad, and obtuse; the nostrils oval and small; the tail moderate, even, or rounded, often with the middle feathers and their coverts recurved.

Of this genus, the most common species in Europe is that which is supposed to be the original of the domestic duck, and which with us is named the wild duck or mallard, *Anas boschas*. The male is a very beautiful bird, having the head and upper part of the neck deep green, the latter with a white ring; the four middle tail-feathers recurved; the upper parts marked with fine undulated grayish-brown and white lines, the breast deep chesnut, the lower parts grayish white, undulated with grayish-brown lines; the alar spot green, edged above and below with white. It inhabits all the northern countries of the globe, and is common in Britain, where it breeds, forming its nest of withered plants in marshy places, and laying from ten to fifteen bluish-white eggs. Instances have occurred of its occupying the deserted nest of a crow. Its flesh is justly held in great estimation, and vast numbers are shot and caught in decoys. The following account of the method employed in capturing wild ducks in the fens of Lincolnshire is given by Bewick.

"In the lakes where they resort, the most favourite haunts of the fowl are observed: then in the most sequestered part of this haunt they cut a ditch about four yards across at the entrance, and about fifty or sixty yards in length, decreasing gradually in width from the entrance to the farther end, which is not more than two feet wide. It is of a semicircular form, but not bending much for the first ten yards. The banks of the lake, for about ten yards on each side of this ditch (or pipe, as it is called), are kept clear from reeds, coarse herbage, &c. in order that the fowl may get on them to sit and dress themselves. Across this ditch, poles on each side, close to the edge of the ditch, are driven into the ground, and the tops bent to each other, and tied fast. These poles at the entrance form an arch, from the top of which to the water is about ten feet. This arch is made to decrease in height as the ditch decreases in width, till the farther end is not more than eighteen inches in height. The poles are placed about six feet from each other, and connected together by poles laid lengthwise across the arch, and tied together. Over them a net with meshes sufficiently small to prevent the fowl getting through is thrown across, and made fast to a reed fence at the entrance, and nine or ten yards up the ditch, and afterwards strongly pegged to the ground. At the farther end of the pipe a tunnel-net, as it is called, is fixed, about four yards in length, of a round form, and kept open by a number of hoops about eighteen inches in diameter, placed at a small distance from each other to keep it distended. Supposing the circular bend of the pipe to be to the right, when you stand with your back to the lake, on the left-hand side, a number of reed-fences are constructed, called shootings, for the purpose of screening from sight the *decoy-man*, and in such a manner that the fowl in the decoy may not be alarmed when he is driving those in the pipe: these shootings are about four yards in length, and about six feet high, and are ten in number. From the end of the last shooting a person cannot see the lake, owing to the bend in the pipes: there is then no farther occasion for shelter. Were it not for these shootings, the fowl that remain about the mouth of the pipe would be alarmed, if the person driving the fowl already under the net should be exposed, and would become so shy as to forsake the place entirely. The first thing the decoy-man does when he approaches the pipe, is to take a piece of lighted turf or peat, and hold it near his mouth, to prevent the fowl smelling him. He is attended by a dog taught for the purpose of assisting him; he walks very silently about half-way up the shootings, where a small piece of wood is thrust through the reed fence, which makes an aperture just sufficient to see if any fowl are in; if not, he walks forward to see if any are about the mouth of the pipe. If there are, he stops and makes a motion to his dog, and gives him a piece of cheese or something to eat; upon receiving it, he goes directly to a hole in the reed-fence, and the fowl immediately fly off the bank into the water; the dog returns along the bank between the reed-fences and the pipe, and comes out to his master at another hole. The man now gives him another reward, and he repeats his round again, till the fowl are attracted by the motion of the dog, and follow him into the mouth of the pipe. This operation is called working them. The man now retreats farther back, working the dog at different holes till the fowl are directly under the net; he now commands his dog to lie down still behind the fence, and goes forward to the end of the pipe next the lake, where he takes off his hat, and gives it a wave between the shooting; all the fowl under the net can see him, but none that are in the lake can. The fowl that are in sight fly forward, and the man runs forward to the next shooting and waves his hat, and so on, driving them along till they come to the tunnel-net, where they creep in: when they are all in he gives the net a twist, so as to prevent their getting back; he then takes the net off from the end of the pipe with what fowl he may have caught, and takes them out one at a time, and dislocates their necks, and hangs the net on again, and all is ready for working again. In this manner five or six dozen have been taken at one drift. When the wind blows directly in or out of the pipes, the fowl seldom work well, especially when it blows in. If many pipes are made in the lake, they are so constructed as to suit different winds."[1] The better to entice the fowl into the pipe, hempseed is strewed occasionally in the water. The season allowed by act of parliament for catching these birds in this way is from the latter end of October till February.

The Chinese duck, *Anas galericulata*, with a pendent crest, and the inner wing-feathers enlarged and raised in a vertical direction, is an extremely beautiful species, a native of China and Japan.

The summer duck, *Anas sponsa*, which also has a pendent crest, is not less beautiful. (Plate XVIII., figure 8.) It inhabits Mexico and other parts of North America, migrating northward in summer, rarely visiting the seashore or salt marshes, but frequenting the muddy creeks, ponds, and mill-dams of the interior.

The tree duck, *Anas arborea*, of a gray colour, the ab-

[1] *British Birds*, vol. ii. p. 294.

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domen spotted with black and white, and the head slightly crested, inhabits the warmer parts of America, and is remarkable for building in the holes of decayed trees.

The gadwall or gray, *Anas strepera*, the Dominican duck, *A. Dominicana*, the Spanish duck, *A. viduata*, and many other species, belong to this genus,—which might include the teals, although these are separated by several authors.

The wigeons, genus MARECA, may be distinguished from the ducks, as they have the bill shorter than the head, higher than broad at the base, depressed and narrowed towards the end; the lamellæ slightly projecting; the tail short and acute. They are, however, very intimately allied to the pintails.

Of this genus one of the best examples is the common wigeon, *Mareca Penelope*, which has the forehead yellowish white, the rest of the head and the neck chesnut-red, the back and flanks undulated with black and white. The male of this species has been known to pair with the female pintail, and produce a hybrid brood. It also pairs with the common duck. Wigeons are abundant in winter in many parts of Britain, and are very much esteemed for the table.

The teals, genus QUERQUEDULA, are distinguished from the other groups by their diminutive size. Their bill is narrower than that of the wigeons, proportionally longer, and has its base more elevated. The species are generally very beautiful.

The garganey teal, *Querquedula circia*, of a gray colour, variegated with black, and having a white streak above the eyes, with a green spot on the wing, inhabits the more temperate parts of Europe, and is abundant in Holland during its winter migration.

The common teal, *Querquedula crecca*, which has the head brownish red, the body transversely undulated with dusky, a white line above and another beneath the eye, and the alar spot black and green, is plentiful in many parts of Europe and North America; while the blue-winged teal, *Q. discors*, characterized by the light blue colour of the wing-coverts, is peculiar to the latter continent, as is likewise the American teal, *Q. Carolinensis*.

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The second principal group named *Mergidæ*, consisting of the genus MERGUS of Linnæus, includes the remaining birds of the great family of Lamellirostres, which are usually designated by the vernacular name of *mergansers*. They differ from the ducks in having their bill slender, almost cylindrical, and furnished on the margins with dentiform points directed backwards, and resembling the teeth of a saw. (Plate XVIII., figure 6.) Their summer residence is in the colder regions of both continents, whence they migrate southward on the approach of winter. Their body is elongated and depressed, their feet short and placed far behind, their wings rather long and narrow, their neck of moderate length. They fly with rapidity, swim and dive with the greatest facility, and generally feed on fishes. In their habits they are intermediate between the ducks and divers; but in their organization and plumage they are more nearly allied to the former. Their tracheæ, besides having an exceedingly large dilatation at its bifurcation, is also enlarged previous to its entrance into the thorax. In accordance with their piscivorous propensities, their gullet is wider than that of the ducks, and their gizzard less muscular.

Three species occur in the temperate parts of Europe. The goosander, *Mergus merganser*, of which the male is black, with the lower parts buff-coloured, and the head purplish green, with a slender elongated crest; the red-breasted merganser, *M. serrator*, about the size of the mallard, also crested, the male black above, white beneath, with the head dark green; and the smew, *M. albellus*, which is smaller than the golden-eye, varied with black and white, and having a large compressed white crest. All these occur also in the northern parts of America, which has moreover a species peculiar to itself, the hooded merganser (*M. cucullatus*, Plate XVIII., figure 7), of a blackish colour above, white beneath, with a semicircular black crest, white on each side. The females and young of all the species differ greatly in colour from the adult males. (J. W.)

THE ORDERS, FAMILIES, AND GENERA, OF BIRDS, ACCORDING TO THE SYSTEM OF ILLIGER.

ORDER I.—SCANSORES.

Family *Psittacini*.....	Gen. Psittacus, Pezoporus (*πεζοπορος*, pedester).
Family *Serrati*.....	Gen. Rhamphastos, Pteroglossus (*πτερον, penna, γλωσσα, lingua*), Pogonias (*πωγωνιας, barbatus*), Corythaix (*κορυθαιξ, galea, cristam movens*), Trogon, Musophagа.
Family *Amphiboli*.....	Gen. Crotophaga, Scythrops, Bucco, Cuculus, Centropus (*κεντρον, stimulus, calcar; πους, pes*).
Family *Sagittilingues*.....	Gen. Yunx, Picus.
Family *Syndactyli*.....	Gen. Galbula.

ORDER II.—AMBULATORES.

Family *Angulirostres*.....	Gen. Alcedo, Merops.
Family *Suspensi*.....	Gen. Trochilus.
Family *Tenuirostres*.....	Gen. Nectarinia (*nectar florum haurientes*), Tichodroma (*τειχος, murus, δρομος, cursitans*), Upupa.

[1] *Prodromus Mammalium et Avium*, Berlin, 1811.

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Family *Pygarrhichi*..... Gen. Certhia, Dendrocolaptes

Family *Gregarii*..... Gen. Xenops (ξενος, *inusitatus, novus*, ωψ, *vultus*), Sitta, Buphaga, Oriolus, Cassicus, Sturnus.

Family *Canori*..... Gen. Turdus, Cinclus, Accentor, Motacilla, Muscicapa, Myiothera (μυια, *musca*, θηραω, *venor, capto*), Lanius, Sparactes (σπαραχτης, *lanio, lacerator*), Todus, Pipra.

Family *Passerini*..... Gen. Parus, Alauda, Emberiza, Tanagra, Fringilla, Loxia, Colius, Glaucopis, Phytotoma.

Family *Dentirostres*..... Gen. Prionites (πριων, *serra*), Buceros.

Family *Coraces*..... Gen. Corvus, Coracias, Paradisea, Cephalopterus, Gracula.

Family *Sericati*..... Gen. Ampelis, Procnias.

Family *Hiantes*..... Gen. Hirundo, Cypselus, Caprimulgus.

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Order III.—Raptores.

Family *Nocturni*..... Gen. Strix.

Family *Accipitrini*..... Gen. Falco, Gypogeranus (γυψ, *vultur*, γερανος, *grus*), Gypaëtus.

Family *Vulturini*..... Gen. Vultur, Cathartes (καθαρτης, *purgator*).

Order IV.—Rasores.

Family *Gallinacei*..... Gen. Numida, Meleagris, Penelope, Crax, Opisthocomus (Hoffmansegg, οπισθοκομος, *occipite comatus*), Pavo, Phasianus, Gallus, Menura, Tetrao, Perdix.

Family *Epollicati*..... Gen. Ortygis (ορτυξ, *coturnix*), Syrrhaptes (συρραπτειν, *consuere*).

Family *Columbini*..... Gen. Columba.

Family *Crypturi*..... Gen. Crypturus (κρυπτειν, *occultare*, ουρη, *cauda*).

Family *Inepti*..... Gen. Didus.

Order V.—Cursores.

Family *Proceri*..... Gen. Casuarius, Struthio, Rhea.

Family *Campestres*..... Gen. Otis.

Family *Littorales*..... Gen. Charadrius, Calidris, Himantopus, Hæmatopus, Tachydromus (ταχυδρομος, *velociter currens*), Burhinus.

Order VI.—Grallatores.

Family *Vaginati*..... Gen. Chionis.

Family *Alectorides*..... Gen. Glareola, Cereopsis, Dicholophus (διχα, *bifariam*; λοφος, *crista*), Palamedea, Chauna (χαυνος, *fungosus, inflatus, inanis*), Psophia.

Family *Herodii*..... Gen. Grus, Ciconia, Ardea, Eurypyga (ευρυς, *latus*, πυγη, *anus, cauda*), Scopus, Cancroma, Anastomus.

Family *Falcati*..... Gen. Tantalus, Ibis.

Family *Limicolæ*..... Gen. Numenius, Scolopax, Ereunetes (ερευνητης, *explorator*), Actitis (ακτιτις, *in littore degens*), Strepsilas (στρεφειν, *vertere*, λαξ, *lapis*), Tringa.

Family *Macrodactyli*..... Gen. Parra, Rallus, Crex.

Family *Lobipedes*..... Gen. Fulica, Podoa (πους, *pes*, ωα, *limbus, fimbria*), Phalaropus.

Family *Hygrobatæ*..... Gen. Corrira, Recurvirostra, Platalea, Phænicopterus.

Order VII.—Natatores.

Family *Longipennes*..... Gen. Rhyncops, Sterna, Larus, Lestris (λῃστρις, *prædatrix*).

Family *Tubinares*..... Gen. Procellaria, Haladroma (αλαδρομας, *in mare cursitans*), Pachyptila (παχυς, *densus*, πτιλον, *pluma*), Diomedea.

Family *Lamelloso-dentati*... Gen. Anas, Anser, Mergus.

Family *Steganopodes*..... Gen. Pelecanus, Halieus (αλευς, *piscator*), Dysporus, Phaëton, Plotus.

Family *Pygodopes*..... Gen. Colymbus, Eudytes (ευ, *bene, facile*, δυτης, *urinator*), Uria, Mormon (μορμων, *larva*), Alca.

Family *Impennes*..... Gen. Aptenodytes.

Temminck's and Vigors's Systems.

THE ORNITHOLOGICAL SYSTEM OF M. TEMMINCK.[1]

Order I.—Rapaces.

Genera.—Vultur, Cathartes, Gypætus, Gypogeranus, Falco, Strix.

Order II.—Omnivores.

Genera.—Opisthocomus, Buceros, Prionites, Corvus, Nucifraga, Pyrrhocorax, Barita, Glaucopis, Gracula, Buphaga, Bombycivora, Ptilonorhynchus, Coracias, Colaris, Oriolus, Icterus, Sturnus Pastor, Paradisea, Lamprotornis.

Order III.—Insectivores.

Genera.—Turdus, Cinclus, Menura, Pitta, Myothera, Tamnophilus, Vanga, Lanius, Psaris, Sparactes, Ocypterus, Criniger, Edolius, Ceblepyris, Coracina, Ampelis, Casmarhinchos, Procnias, Rupicola, Phibalura, Pipra, Pardalotus, Todus, Platyrhinchos, Muscipeta, Muscicapa, Malurus, Sylvia, Saxicola, Accentor, Motacilla, Anthus.

Order IV.—Granivores.

Genera.—Alauda, Parus, Emberiza, Tanagra, Ploceus, Loxia, Psittirostra, Pyrrhula, Fringilla, Phytotoma, Colius.

Order V.—Zygodactyli.

First Family.

Genera.—Musophaga, Indicator, Cuculus, Coccyzus, Centropus, Phœnicophaus, Leptosomus, Scythrops, Pteroglossus, Ramphastos, Crotophaga, Trogon, Capito, Bucco, Pogonias, Psittacus.

Second Family.

Genera.—Picus, Yunx.

Order VI.—Anisodactyli.

Genera.—Oxyrincus, Orthonyx, Dendrocolaptes, Xenops, Anabates, Opetiorynchos, Certhia, Cereba, Trochilus, Nectarinia, Climacteris, Tichodroma, Upupa, Epimachus, Drepanis, Meliphaga.

Order VII.—Alciones.

Genera.—Merops, Alcedo, Dacelo.

Order VIII.—Chelidones.

Genera.—Hirundo, Cypselus, Caprimulgus.

Order IX.—Columbæ.

Genus.—Columba.

Order X.—Gallinæ.

Genera.—Pavo, Gallus, Phasianus, Lophophorus, Polyplectron, Meleagris, Argus, Numida, Pauxi, Crax, Penelope, Tetrao, Pterocles, Syrrhaptes, Perdix, Cryptonyx, Tinamus, Hemipodius.

Order XI.—Alectorides.

Genera.—Psophia, Dicholophus, Glareola, Palamedea, Chauna.

Order XII.—Cursores.

Genera.—Struthio, Rhea, Casuarius, Otis, Cursorius.

Order XIII.—Grallatores.

First Family.

Genera.—Œdicnemus, Calidris, Falcinellus, Himantopus, Hæmatopus, Charadrius.

Second Family.

Genera.—Vanellus, Strepsilus, Grus, Aramus, Ardea, Ciconia, Anastomus, Scopus, Phœnicopterus, Recurvirostra, Cancroma, Platalea, Tantalus, Ibis, Numenius, Tringa, Totanus, Limosa, Scolopax, Rynchæa, Eurypyga, Rallus, Gallinula, Parra, Porphyrio.

Order XIV.—Pinnatipedes.

Genera.—Fulica, Podoa, Phalaropus, Podiceps.

Order XV.—Palmipedes.

Genera.—Cereopsis, Chionis, Rynchops, Sterna, Larus, Lestris, Procellaria, Pachyptila, Haladroma, Diomedea, Anas, Mergus, Pelecanus, Carbo, Tachypetes, Sula, Plotus, Phaëton, Uria, Phaleris, Mormon, Alca, Sphenisicus, Aptenodytes.

Order XVI.—Inertes.

Genera.—Apteryx, Didus.

THE CLASSIFICATION OF BIRDS, AS PROPOSED BY MR VIGORS.[2]

Order I.—Raptores, Ill. (Accipitres, Linn.)

1st Family. —— ?—Gen. Gypogeranus, Ill. (Serpentarius, Cuv.; Ophiotheres, Vieill.).

2d Family. Vulturidæ.—1. —— Gen. Cathartes, Ill. (Catharista, Vieill.); 2. —— Gen. Sarcoramphus, Dum. (Cathartis pars, Ill.; Gypagus, Vieill.); 3. —— Gen. Gyps, Sav.; Vultur, Auct. (Ægypius, Sav.); 4. —— Gen. Gypætus, Storr. (Phene, Sav.); 5. —— Gen. Neophron, Sav. (Cathartis pars, Temm.).

3d Family. Falconidæ, Leach.—1. Sub-fam. *Aquilina.* Gen. Ibycter, Vieill.; Daptrius, Vieill.; Polyborus, Vieill.; Pandion, Sav.; Haliætus, Sav.; Aquila, Auct.; Harpyia, Cuv.; Physeta, Vieill.; Morphnus, Cuv. (Spizaëtus, Vieill.); Cymindis, Cuv.; Asturina, Vieill. 2. Sub-fam. *Accipitrina.* Gen. Dædalion, Sav.; Astur, Auct. (Sparvius, Vieill.); Accipiter, Auct.; Harpagus; Gampsonyx. 3. Sub-fam. *Falconina.* Gen. Hierax, Vig.; Falco, Auct. 4. Sub-fam. *Buteonina.* Gen. Ictinia, Vieill.; Circus, Auct.; Pernis, Cuv.; Buteo, Auct. 5. Sub-fam. *Milvina.* Gen. Elanus, Sav.; Nauclerus, Vig.; Milvus, Auct.

4th Family. Strigidæ, Leach.—1. Sub-fam. *Noctuina.* Gen. Surnia, Dum.; Noctua, Sav. 2. Sub-fam. *Bubonina.* Gen. Scops, Sav.; Bubo, Cuv. 3. Sub-fam. *Asionina.* Gen. Asio, Antiq. (Olus, Cuv.). 4. Sub-fam. *Strigina.* Gen. Ulula, Cuv.; Strix, Auct. 5. Sub-fam. *Syrniana.* Gen. Syrnium, Linn.

5th Family. —— ?

[1] From the *Manuel d'Ornithologie*, i. xlviii. 1820.

[2] In the *Zoological Journal*, No. vii. p. 392. 1825.

Vigors's System.

ORDER II.—INSESSORES. (Picæ, Passeres, Linn.)

Tribe I.—Fissirostres, Cuv.

1st FAMILY. MEROPIDÆ.—Gen. Merops, Linn. (Apiaster, Briss.).

2d FAMILY. HIRUNDINIDÆ.—Gen. Cypselus, Ill. (Apus, Cuv.; Micropus, Meyer); Hirundo, Auct.

3d FAMILY. CAPRIMULGIDÆ.—Gen. Caprimulgus, Auct.; Podargus, Cuv.; Ægotheles, Vig. and Hors.; Steatornis, Humb.; Nyctebius, Vieill.

4th FAMILY. TODIDÆ.—Gen. Eurylaimus, Horsf.; Eurystomus, Vieill. (Colaris, Cuv.); Todus, Auct.

5th FAMILY. HALCYONIDÆ.—Gen. Alcedo, Linn. (Ispida, Briss.); Halcyon, Swains.; Dacelo, Leach; Tanysiptera, Vig.; Galbula, Briss.; Capito, Vieill.? Monasa, Vieill.?

Tribe II.—Dentirostres, Cuv.

1st FAMILY. MUSCICAPIDÆ.—Gen. Platyrhynchus, Desm.; Muscicapa, Auct.; Muscipeta, Cuv.; Onychorhynchus, Fisch.; Vireo, Vieill.? Icteria, Vieill.?

2d FAMILY. LANIADÆ.—1. Sub-fam. *Tyrannina*, Swains. Gen. Tyrannus, Cuv.; Tityra, Vieill. (Psaris, Cuv.); Gubernetes, Such. 2. Sub-fam. *Dicrurina*, Swains. Gen. Artamus, Vieill. (Ocypterus, Cuv.); Dicrurus, Vieill. (Edolius, Cuv.); Trichophorus, Temm.? Irena, Horsf. 3. Sub-fam. *Laniana*, Swains. Gen. Sparactes, Ill.; Lanius, Auct.; Falcunculus, Vieill.; Cyclarhis, Swains.; Lanio, Vieill.? 4. Sub-fam. *Thamnophilina*, Swains. Gen. Vanga, Cuv.; Thamnophilus, Vieill.; Malaconotus, Swains.; Formicivora, Swains.; Drymophila, Swains.; Laniarius, Vieill.; Prionops, Vieill. 5. Sub-fam. *Campephagina*, Swains. Gen. Grauculus, Cuv.; Campephaga, Vieill. (Ceblepyris, Cuv.).

3d FAMILY. MERULIDÆ.—1. Sub-fam. *Myotherina*, Swains. Gen. Urotomus, Swains.; Myothera, Ill. (Myrmothera, Vieill.); Pitta, Vieill.; Grallaria, Vieill.; Conophaga, Vieill.; Cinclus, Bechst.? (Hydrobata, Vieill.); Chamæza, Vig. 2. Sub-fam. *Merulina*. Gen. Merula, Ray; Sphecotheres, Vieill.? 3. Sub-fam. *Oriolina*. Gen. Oriolus, Auct. 4. Sub-fam. *Cossyphina*. Gen. Cossypha, Vig.; Timalia, Horsf.? 5. Gen. Petrocincla, Vig.

4th FAMILY. SYLVIADÆ.—1. ——? Gen. Hylophilus, Temm.; Iora, Horsf.; Accentor, Bechst.; Prunella, Gessn.? 2. ——? Gen. Brachypteryx, Horsf.; Curruca, Bechst.; Ficedula, Bechst.; Œgithina, Vieill.? 3. Sub-fam. *Sylviana*. Gen. Sylvia, Auct.; Melizophilus, Leach; Synallaxis, Vieill.; Malurus, Vieill.; Troglodytes, Cuv.; Regulus, Cuv.; Tyrannulus, Vieill. 4. Sub-fam. *Motacillina*. Gen. Motacilla, Auct.; Budytes, Cuv.; Enicurus, Temm.; Anthus, Bechst.; Corydalla, Vig.; Megalurus, Horsf. 5. Sub-fam. *Saxicolina*. Gen. Saxicola, Bechst. (Œnanthe, Vieill.).

5th FAMILY. PIPRIDÆ.—Gen. Ægithalus, Vig.; Parus, Linn.; Megistina, Vieill.; Pardalotus, Vieill.; Pipra, Linn. (Manacus, Briss.); Rupicola, Briss.; Calyptomena, Raffles; Phibalura, Vieill.; Bombicilla, Briss.; Ampelis, Auct. (Cotinga, Briss.; Tersa, Vieill.); Procnias, Hoffm.; Casmarhynchus, Temm. (Ampelis, Vieill.); Querula, Vieill.; Coracina, Vieill. (Cephalopterus, Geoff.); Pachycephala, Swains.

Tribe III.—Conirostres, Cuv.

1st FAMILY. FRINGILLIDÆ.—1. Sub-fam. *Tanagrina?* Gen. Euphonia, Vieill.; Nemosia, Vieill.; Tachyphonus, Vieill.; Saltator, Vieill.; Tanagra, Auct.; Pyranga, Vieill.; Ramphopis, Vieill.; Arremon, Vieill.; Dulus, Vieill.? Pipilo, Vieill. 2. Sub-fam. *Alaudina*. Gen. Emberiza, Linn.; Passerina, Vieill.; Alauda, Auct.; Mirafra, Horsf. 3. Sub-fam. *Carduelina*. Gen. Carduelis, Briss.; Ploceus, Cuv. (Agelaii pars, Vieill.). 4. Sub-fam. *Passerina*. Gen. Fringilla, Auct.; Passer, Auct. (Pyrgita, Cuv.). 5. Sub-fam. *Pyrrhulina?* Gen. Linaria, Bechst.; Vidua, Cuv.; Pyrrhula, Briss.? Vigors's System.

2d FAMILY. STURNIDÆ.—1. Sub-fam. *Icterina*. Gen. Xanthornus, Cuv. (Yphantes, Vieill.); Icterus, Cuv. (Pendulinus, Vieill.); Sycobius, Vieill.? Quiscalus, Vieill.; Cassicus, Daud.; Leïstes (Agelaii pars, Vieill.). 2. Sub-fam. *Sturnina*. Gen. Sturnella, Vieill.; Sturnus, Linn.; Amblyramphus, Leach; Dilophus, Vieill.? 3. ——? Gen. Lamprotornis, Temm.; Acridotheres, Vieill. (Gracula, Cuv.). 4. ——? Gen. Pastor, Temm. (Psaroidos, Vieill.); Grallina, Vieill.? 5. ——? Gen. Buphaga, Linn.

3d FAMILY. CORVIDÆ, Leach.—1. ——? Gen. Cracticus, Vieill. (Barita, Cuv.); Nucifraga, Briss. 2. Sub-fam. *Corvina*. Gen. Pica, Briss.; Garrulus, Briss.; Corvus, Auct. 3. Sub-fam. *Coraciana*. Gen. Coracias, Linn. (Galgulus, Briss.); Gracula, Auct. (Eulabes, Cuv.); Ptilonorhynchus, Kuhl; Glaucopis, Forst. (Callæas, Lath.); Crypsirina, Vieill. (Phrenotrix, Horsf.). 4. Sub-fam. *Paradiseana*. Astrapia, Vieill.; Parotia, Vieill.; Paradisea, Linn. (Manucodiata, Briss.); Lophorina, Vieill.; Cicinnurus, Vieill.; Epimachus, Cuv.? 5. ——? Gen. Fregilus, Cuv. (Coracias, Briss.); Pyrrhocorax, Vieill.

4th FAMILY. BUCERIDÆ, Leach.—Gen. Buceros, Linn. (Hydrocorax, Briss.); Momotus, Briss. (Prionites, Ill.; Baryphonus, Vieill.).

5th FAMILY. LOXIADÆ.—Gen. Phytotoma, Gmel.; Coccothraustes, Briss.; Pytilus, Cuv.; Loxia, Briss.; Psittirostra, Temm.; Colius, Linn.? Cissopis, Vieill. (Bethylus, Cuv.); Strobilophaga, Vieill. (Corythus, Cuv.).

Tribe IV.—Scansores, Auct.

1st FAMILY. RAMPHASTIDÆ.—Gen. Scythrops, Lath.; Ramphastos, Linn. (Tucana, Briss.); Pteroglossus, Ill.

2d FAMILY. PSITTACIDÆ, Leach.—1. Sub-fam. *Psittacina*. Gen. Psittacus, Auct.; Androglossa. 2. Sub-fam. *Plyctolophina*. Gen. Plyctolophus, Vieill.; Calyptorhynchus, Vig. and Hors.; Microglossum, Geoff. 3. Sub-fam. *Macrocercina*. Gen. Macrocercus, Vieill. 4. Sub-fam. *Palæornina*. Gen. Psittacara: Nanodes, Vig. and Hors.; Platycercus; Pezoporus, Ill.; Palæornis, Vig.; Trichoglossus, Vig. and Hors.; Lorius, Vig.; Brotogeris, Vig. 5. Sub-fam. *Psittaculina*. Gen. Psittacula, Kuhl.

3d FAMILY. PICIDÆ.—Gen. Pogonias, Ill.; Bucco, Auct.; Picus, Linn.; Colaptes, Swains.; Yunx, Linn. (Torquilla, Briss.).

4th FAMILY. CERTHIADÆ.—Gen. Dendrocolaptes, Herm. (Dendrocopus, Vieill.); Certhia, Auct.; Climacteris, Temm.; Orthonyx, Temm.; Tichodroma, Ill. (Petrodroma, Vieill.); Upupa, Linn.; Sitta, Linn.; Xenops, Hoffm.; Orthotomus, Horsf.; Neops, Vieill.; Mniotilta, Vieill.; Thriothurus, Vieill.; Pyrrota, Vieill.? Opetiorhynchus, Temm.; Oxyrhynchus, Temm.

5th FAMILY. CUCULIDÆ, Leach.—Gen. Coccyzus, Vieill.; Leptosomus, Vieill.; Cuculus, Auct.; Indicator, Vieill.; Centropus, Ill. (Corydonyx, Vieill.); Saurothera, Vieill.; Phænicophaus, Vieill.; Crotophaga, Linn.; Trogon, Linn.; Corythaix, Ill.? (Opæthus, Vieill.); Musophaga, Isert.?

Tribe V.—Tenuirostres, Cuv.

1st FAMILY. NECTARINIADÆ?—Gen. Nectarinia, Ill.; (Cæreba, Vieill.); Dacnis, Cuv.; Furnarius, Vieill.?

2d FAMILY. CYNNYRIDÆ.—Gen. Cinnyris, Cuv. (Mellisuga, Vieill.); Dicæum, Cuv.; Drepanis, Temm.

3d FAMILY. TROCHILIDÆ.—Gen. Trochilus, Auct. (Polytmus, Briss.); Mellisuga, Briss. (Orthorhynchus, Lacepede).

4th FAMILY. PROMEROPIDÆ.—Gen. Promerops, Briss. (Falcinellus, Vieill.).

5th FAMILY. MELIPHAGIDÆ.—Gen. Meliphaga, Lewin

Swainson's System.

(Philedon, Cuv.; Philemon, Vieill.); Melithreptus, Vieill.; Creadion, Vieill.; Mimetes, King? Sericulus, Swains.? Ptiloris, Swains.; Pomatorhinus, Horsf.? Prinia, Horsf.?

ORDER III.—RASORES, Ill. (Gallinæ, Linn.)

1ST FAMILY. COLUMBIDÆ, Leach.—Gen. Treron, Vieill. (Vinago, Cuv.); Columba, Auct.; Ptilinopus, Swains.; Lophyrus, Vieill.

2D FAMILY. PHASIANIDÆ.—Gen. Meleagris, Linn. (Gallopavo, Briss.); Pavo, Linn.; Diplectron, Vieill. (Polyplectron, Temm.); Gallus, Briss.; Monaulus, Vieill. (Lophophorus, Temm.); Phasianus, Auct.; Argus, Temm.; Numida, Linn. (Melegris, Briss.).

3D FAMILY. TETRAONIDÆ, Leach.—Gen. Liponyx, Vieill. (Cryptonyx, Temm.); Odontophorus, Vieill.; Coturnix, Cuv.; Perdix, Briss.; Ganga, Vieill. (Pterocles, Temm.); Tetrao, Auct.; Lagopus, Vieill.; Syrrhaptes, Ill. (Heteroclitus, Vieill.); Ortygis, Ill. (Ortygodes, Vieill.; Hemipodius, Temm.); Tinamus, Lath. (Crypturus, Ill.; Cryptura, Vieill.).

4TH FAMILY. STRUTHIONIDÆ.—Gen. Rhea, Briss.; Struthio, Linn.; Casuarius, Briss.; Dromiceius, Vieill.; Didus, Linn. (Raphus, Briss.); Otis, Linn.

5TH FAMILY. CRACIDÆ.—Gen. Ourax, Cuv. (Pauxi, Temm.); Crax, Linn.; Penelope, Merr.; Ortalida, Merr.; Opisthocomus, Hoffm.? (Orthocorys, Vieill.); Menura, Lath.; Megapodius, Temm.

ORDER IV.—GRALLATORES, Ill. (Grallæ, Linn.)

1ST FAMILY. GRUIDÆ.—Gen. Psophia, Linn.; Anthropoïdes, Vieill.; Balearica, Briss.; Grus, Pall.; Cariama, Briss. (Dicholophus, Ill.; Zophorhynchus, Vieill.; Macrodactylus, Geoff.).

2D FAMILY. ARDEIDÆ, Leach.—Gen. Aramus, Vieill.; Eurypyga, Ill. (Helias, Vieill.); Ardea, Auct.; Canchroma, Linn. (Cochlearius, Briss.); Phænicopterus, Linn.; Platalea, Linn. (Platea, Briss.); Ciconia, Briss.; Mycteria, Linn.; Scopus, Briss.; Anastomus, Ill. (Hians, Lacep.); Tantalus, Linn.; Ibis, Lacep. (Falcinellus, Bechst.).

3D FAMILY. SCOLOPACIDÆ.—Gen. Numenius, Briss.; Totanus, Bechst. (Actitis pars., Ill.); Recurvirostra, Linn. (Avocetta, Briss.); Limosa, Briss. (Actitis pars., Ill.; Limicula, Vieill.); Ereunetes, Ill.: Macroramphus, Leach? Scolopax, Auct.; Rusticola, Vieill.; Rynchæa, Cuv. (Rostratula, Vieill.); Machetes, Cuv. (Actitis pars., Ill.); Pelida, Cuv.; Phalaropus, Briss. (Crymophilus, Vieill.); Lobipes, Cuv. (Phalaropus, Vieill.); Tringa, Auct. (Actitis pars., Ill.); Phæopus, Cuv.

4TH FAMILY. RALLIDÆ, Leach.—Gen. Parra, Linn. (Jacana, Briss.); Palamedea, Linn. (Anhima, Briss.); Chauna, Ill. (Opistolophus, Vieill.); Glareola, Briss.; Rallus, Auct.; Chionis, Forst.? (Vaginalis, Gmel.); Crex, Bechst. (Ortygometra, Steph.); Gallinula, Briss.; Porphyrio, Briss.; Podoa, Ill. (Heliornis, Vieill.); Fulica, Auct. Swainson's System.

5TH FAMILY. CHARADRIADÆ, Leach.—Gen. Hæmatopus, Linn. (Ostralega, Briss.); Calidris, Ill. (Arenaria, Briss.); Falcinellus, Cuv.: Erolia, Vieill.? Cursorius, Lath. (Tachydromus, Ill.); Strepsilas, Ill.; Squatarola, Cuv.; Vanellus, Briss. (Tringa, Ill.); Pluvianus, Vieill.; Charadrius, Auct. (Pluvialis, Briss.); Burhinus, Ill.? Himantopus, Briss. (Macrotarsus, Lacep.); Œdicnemus, Cuv.

ORDER V.—NATATORES, Ill. (Anseres, Linn.)

1ST FAMILY.—ANATIDÆ, Leach.—1. Sub-fam. *Anserina.* Gen. Anser, Briss.; Bernicla, Steph.; Cheniscus, Brookes's MS.; Chenalopex, Steph.; Plectropterus, Leach. 2. Sub-fam. *Cereopsina.* Gen. Cereopsis, Lath. 3. Sub-fam. *Anatina.* Gen. Tadorna, Leach; Cairina, Flem.; Anas, Auct.; Dafila, Leach; Mareca, Steph.; Querquedula, Ray; Rhynchaspis, Leach. 4. Sub-fam. ——? Gen. Clangula, Flem.; Harelda, Ray; Fuligula, Ray; Mergus, Linn. (Merganser, Briss.); Somateria, Leach; Oidemia, Flem.; Biziura, Leach. 4. Sub-fam. *Cygnina.* Gen. Cygnus, Meyer.

2D FAMILY. COLYMBIDÆ, Leach.—Gen. Podiceps, Lath. (Colymbus, Briss. Ill.); Colymbus, Auct. (Mergus, Briss.; Eudytes, Ill.).

3D FAMILY. ALCADÆ.—Gen. Uria, Briss.; Cephus, Cuv.? Mergulus, Ray; Phaleris, Temm. (Alca, Vieill.); Fratercula, Briss. (Mormon, Ill.; Larvæ pars, Vieill.); Alca, Auct. (Larvæ pars, Vieill.); Spheniscus, Briss.; Catarractes, Briss. (Eudytes, Vieill.); Aptenodytes, Forst.

4TH FAMILY. PELECANIDÆ, Leach.—Gen. Onocrotalus, Briss.; Phalacrocorax, Briss. (Carbo, Meyer; Haliæus, Ill.; Hydrocorax, Vieill.); Sula, Briss. (Dysporus, Ill.; Morus, Vieill.); Tachypetes, Vieill.; Phaëton, Linn. (Lepturus, Briss.); Plotus, Linn. (Anhinga, Briss.).

5TH FAMILY. LARIDÆ, Leach.—Gen. Sterna, Linn.; Rhynchops, Linn. (Rygchopsalia, Briss.); Larus, Auct.; Stercorarius, Briss. (Lestris, Ill.; Prædatrix, Vieill.); Diomedea, Linn. (Albatrus, Briss.); Haladroma, Ill. Procellaria, Auct.; Pachyptila, Ill.; Puffinus, Ray; Thalassidroma, Vig.

THE ORDERS, FAMILIES, AND SUB-FAMILIES OF BIRDS, ACCORDING TO THE SYSTEM OF MR SWAINSON.[1]

ORDER I.—RAPTORES. RAPACIOUS BIRDS.

FAMILY VULTURIDÆ. Vultures.

FAMILY FALCONIDÆ. Falcons.—Sub-families: Aquilinæ, Eagles; Cymindinæ, Kites; Buteoninæ, Buzzards; Falconinæ, Falcons; Accipitrinæ, Hawks.

FAMILY STRIGIDÆ. Owls.

ORDER II.—INSESSORES. PERCHING BIRDS.

Tribe I.—Dentirostres.

FAMILY LANIADÆ. Shrikes.—Sub-families: Lanianæ, True Shrikes; Thamnophilinæ, Bush Shrikes; Dicrurinæ, Drongo Shrikes; Ceblepyrinæ, Caterpillar-catchers; Tyranninæ, Tyrant Shrikes.

FAMILY MERULIDÆ. Thrushes.—Sub-families: Brachypodinæ, Short-footed Thrushes; Myotherinæ, Ant Thrushes; Merulinæ, True Thrushes; Crateropodinæ, Babblers; Oriolinæ, Orioles.

FAMILY SYLVIADÆ. Warblers.—Sub-families: Saxicolinæ, Stonechats; Philomelinæ, Nightingales; Sylvianæ, True Warblers; Parianæ, Tit-mice; Motacillinæ, Wagtails.

FAMILY AMPELIDÆ. Fruit-eaters, or Chatterers.—Sub-

[1] From the *Natural History and Classification of Birds*, vol. ii. p. 205, published in Dr Lardner's *Cabinet Cyclopædia*, vol. xcii. 1837. The accessible form of this recent work renders it less necessary that we should give a full exposition of its systematic portion, and the great amount of its generic groups renders their insertion somewhat incompatible with those prescribed limits which in truth we have already exceeded. But we take it for granted, that every sincere lover of Ornithology will possess himself of Mr Swainson's volumes, to which any abstract we could offer would do injustice.

Birds of Europe.

families: Leiotrichanæ, Silky Chatterers? Vireoninæ, Greenlets and Thick-heads; Bombycillinæ, Swallow-chatterers; Ampelinæ, Typical Chatterers; Piprinæ, Manakins.

Family Muscicapidæ. Fly-catchers.—Sub-families: Querulinæ; Psarianæ, Black-caps; Fluvicolinæ, Waterchats; Muscicapinæ, Fly-catchers; Eurylaiminæ, Broadbills.

Tribe II.—Conirostres.

Family Corvidæ. Crows.—Sub-families: Corvinæ, Typical Crows; Garrulinæ, Jays; Glaucopinæ, Wattle-crows; Coracinæ, Fruit-crows; Frigilinæ.

Family Sturnidæ. Starlings.—Sub-families: Sturninæ, Typical Starlings; Lamprotorninæ, Grakles; Scaphidurinæ, Boat-tails; Icterinæ, Hang-nests; Aglainæ, Maizers.

Family Fringillidæ. Finches.—Sub-families: Coccothraustinæ, Hard-bills; Tanagrinæ, Tanagers; Fringillinæ, Ground-finches; Alaudinæ, Larks; Pyrrhulinæ, Bullfinches.

Family Musophagidæ. Plantain-eaters.—Sub-families: Phitotominæ, Plant-cutters; Colinæ, Colies; Musophaginæ, Plantain-eaters.

Family Buceridæ. Genus Buceros.

Tribe III.—Scansores.

Family Ramphastidæ. Toucans.

Family Psittacidæ. Parrots.—Sub-families: Macrocircinæ, Maccaws; Psittacinæ, Parrots; Plyctolophinæ, Cockatoos; Lorianæ, Lories; Platycircinæ, Loriets.

Family Picidæ. Woodpeckers.—Sub-families: Picianæ, True Woodpeckers; Buccoinæ, Barbuts.

Family Certhiadæ. Creepers.—Sub-families: Certhianæ, True Creepers; Anabatinæ, Tree-runners; Sittinæ, Nut-hatchers; Troglodytinæ, Wrens; Buphaginæ, Ox-peckers.

Family Cuculidæ. Cuckoos.—Sub-families: Cuculinæ, Parasitic Cuckoos; Coccyzinæ, Hook-billed Cuckoos; Leptostominæ, Long-billed Cuckoos; Indicatorinæ, Honey-guides.

Tribe IV.—Tenuirostres. Suctorial Birds.

Birds of Europe.

Family Meliphagidæ. Honey-suckers.
Family Cinnyridæ. Sun-birds.
Family Trochilidæ. Humming birds.
Family Promeropidæ. Hoopoes.
Family Paradisiadæ. Paradise Birds.

Tribe V.—Fissirostres. Fissirostral Birds.

Family Meropidæ. Bee-eaters.
Family Halcyonidæ. King-fishers.
Family Trogonidæ. Trogons.
Family Caprimulgidæ. Night-jars.
Family Hirundinidæ. Swallows.

Order III.—Rasores. Rasorial Birds.

Family Pavonidæ. Peacocks and Pheasants.
Family Tetraonidæ. Partridges and Grouse.
Family Struthionidæ. Ostriches.
Family Columbidæ. Pigeons.—Sub-family: Columbinæ.
Family Megapodiadæ. Great-foots.

Order IV.—Grallatores. Waders.

Family Ardeadæ. Herons and Cranes.
Family Tantalidæ. Ibis.
Family Rallidæ. Rails.
Family Scolopacidæ. Sand-pipers and Snipes.
Family Charadriadæ. Plovers.

Order V.—Natatores. Swimmers.

Family Anatidæ. Ducks.—Sub-families: Phœnicoptinæ, Flamingoes; Anserinæ, Geese and Swans; Anatinæ, River-ducks; Fuligulinæ, Sea-ducks; Merganinæ, Mergansers.
Family Colymbidæ. Grebes and Divers.
Family Alcadæ. Auks.
Family Pelecanidæ. Pelicans.
Family Laridæ.[1] Gulls.

ENUMERATION OF THE BIRDS OF EUROPE.[2]

Order I.—Raptores.

Vultur fulvus, Linn.	Griffon Vulture.
V. cinereus, Linn.	Cinereous Vulture.
Neophron percnopterus, Sav.	Egyptian Neophron.
Gypaëtus barbatus, Storr.	Lammer-geyer.
Aquila imperialis, Briss.	Imperial Eagle.
A. chrysæta, Briss.	Golden Eagle.
A. Bonelli.	Bonelli's Eagle.
A. nævia, Meyer.	Spotted Eagle.
A. pennata, Steph.	Booted Eagle.
Haliæëtus albicilla, Selby.	Sea-Eagle.
H. leucocephalus, Sav.	White-headed Eagle.
Pandion haliæëtus, Sav.	Osprey.
Circætus brachydactylus, Vieill.	Short-toed Eagle.
Buteo vulgaris, Bechst.	Common Buzzard.
B. lagopus, Flem.	Rough-legged Buzzard.
Pernis apivorus, Cuv.	Honey Buzzard.
Astur palumbarius, Bechst.	Goshawk.
Falco islandicus, Lath.	Jer-Falcon.
F. lanarius, Linn.	Lanner Falcon.
Falco peregrinus, Linn.	Peregrine Falcon.
F. subbuteo, Linn.	Hobby.
F. rufipes, Bechst.	Red-footed Falcon.
F. æsalon, Temm.	Merlin.
F. concolor, Temm.	Lead-coloured Falcon.
F. tinnunculus, Linn.	Kestril.
F. tinnunculoides, Natt.	Lesser Kestril.
Milvus vulgaris, Flem.	Kite.
M. ater.	Black Kite.
Nauclerus furcatus, Vig.	Swallow-tailed Kite.
Elanus melanopterus, Leach.	Black-tailed Kite.

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[1] This and the preceding family are placed as sub-families in Mr Swainson's synopsis,—we presume, by an oversight in typographical correction. A similar inadvertency occurs among the tenuirostral tribe.

[2] From Mr Gould's *Birds of Europe*, recently completed in five volumes royal folio, 1837. According to the author of this sumptuous work, the number of European birds may now be stated to amount to 462 species, of which 310 may be regarded as British. Of the latter, about 170 are permanent residents in our island, eighty-five are summer birds of passage, which visit us from the south, and forty-five are winter birds of passage, which visit us from the north. This seems to leave ten species unaccounted for: these may probably be regarded as accidental stragglers. We may add, that Mr Doubleday, in his *Nomenclature of British Birds* (1836), states the total number of species actually killed or captured in Britain as amounting to 323, of which the *Raptores* are thirty, the *Insessores* 117, the *Rasores* seventeen, the *Grallatores* sixty-six, and the *Natatores* ninety-three.

Birds of Europe.

Circus rufus, Briss.	Marsh Harrier.
C. cyaneus, Meyer.	Hen Harrier.
C. pallidus, Sykes.	Pallid Harrier.
C. cineraceus, Meyer.	Ash-coloured Harrier.
Strix flammea, Linn.	Barn Owl.
Bubo maximus, Sibb.	Great-horned or Eagle Owl.
B. ascalaphus, Sav.	Eastern Great-horned Owl.
Otus vulgaris, Flem.	Long-eared Owl.
O. brachyotus, Cuv.	Short-eared Owl.
Scops Aldrovandi, Will. and Ray.	Scops-eared Owl.
Surnia cinerea.	Great Cinereous Owl.
S. nyctea, Dum.	Snowy Owl.
S. Uralensis, Dum.	Ural Owl.
S. funerea, Dum.	Hawk Owl.
Ulula nebulosa, Cuv.	Barred Owl.
Syrnium aluco, Sav.	Tawny or Wood Owl.
Noctua nudipes, Wils.	Little Owl.
N. ? tengmalmi, Selby.	Tengmalm's Owl.
N. passerina.	Sparrow Owl.

ORDER II.—INSESSORES.[1]

Caprimulgus Europæus, Linn.	European Goat-sucker.
C. ruficollis.	Red-collared Goat-sucker.
Cypselus murarius, Temm.	Swift.
C. alpinus, Temm.	White-bellied Swift.
Hirundo rustica, Linn.	Chimney Swallow.
H. rufula, Temm.	Rufous Swallow.
H. rupestris, Linn.	Rock-Martin.
H. urbica, Linn.	Martin.
H. riparia, Linn.	Sand-Martin.
Merops apiaster, Linn.	Bee-eater.
Coracias garrulus, Linn.	Roller.
Alcedo ispida, Linn.	Kingfisher.
A. rudis, Linn.	Black and White Kingfisher.
Muscicapa luctuosa, Temm.	Pied Fly-catcher.
M. albicollis, Temm.	White-collared Fly-catcher.
M. parva, Bechst.	Red-breasted Fly-catcher.
M. grisola, Linn.	Spotted Fly-catcher.
Collurio excubitor, Vig.	Great Shrike.
C. meridionalis, Vig.	Great Gray Shrike.
C. minor, Vig.	Lesser Gray Shrike.
Lanius collurio, Linn.	Red-backed Shrike.
L. rufus, Briss.	Wood-Chat.
Oriolus galbula, Linn.	Golden Oriole.
Merula vulgaris, Ray.	Black Ouzel or Blackbird.
M. torquata, Briss.	Ring-Ouzel.
M. migratoria, Swains.	Migratory Ouzel.
Turdus atrogularis, Temm.	Black-throated Thrush.
T. pilaris, Linn.	Fieldfare.
T. viscivorus, Linn.	Missel-Thrush.
T. musicus, Linn.	Song-Thrush.
T. iliacus, Linn.	Redwing.
T. Naumannii, Temm.	Naumann's Thrush.
T. pallidus, Pall.	Pallid Thrush.
T. Whitei, Eyton.	White's Thrush.
T. Sibericus, Pall.	Siberian Thrush.
Cinclus aquaticus, Bechst.	Water-Ouzel.
C. melanogaster, Brehm.	Black-bellied Water-Ouzel.
C. Pallasii, Temm.	Pallas's Water-Ouzel.
Petrocincla saxatilis, Vig.	Rock-Thrush.
P. cyanea, Vig.	Blue Thrush.
Saxicola cachinnans, Temm.	Black Wheat-ear.
S. leucomela, Temm.	Pied Wheat-ear.
S. œnanthe, Bechst.	Wheat-ear.
S. stapazina, Temm.	Russet Wheat-ear.
S. aurita, Temm.	Black-eared Wheat-ear.
Saxicola rubetra, Bechst.	Whinchat.
S. rubicola, Bechst.	Stonechat.
Phœnicura ruticilla, Swains.	Redstart.
Ph. tithys, Jard. and Selb.	Black Redstart.
Ph. suecica, Jard. and Selb.	Blue-throated Warbler.
Erythaca rubecula, Swains.	Robin.
Accentor alpinus, Bechst.	Alpine Accentor.
A. modularis, Cuv.	Hedge Accentor.
A. montanellus, Temm.	Mountain Accentor.
Locustella fluviatilis.	Reed Locustelle.
L. avicula, Ray.	Brake Locustelle.
L. luscinoides.	Willow Locustelle.
L. certhiola.	Creeping Locustelle.
Salicaria turdoides, Selb.	Great Sedge Warbler.
S. olivetorum, Strickl.	Olive-tree Salicaria.
S. arundinacea, Selb.	Reed Wren.
S. palustris.	Marsh Warbler.
S. phragmitis, Selb.	Sedge Warbler.
S. melanopogon.	Moustached Warbler.
S. aquatica.	Aquatic Warbler.
S. galactotes.	Rufous Sedge Warbler.
S. cisticola.	Fan-tail Warbler.
S. ? Cetti.	Cetti's Warbler.
S. ? sericea.	Silky Warbler.
Philomela luscinia, Swains.	Nightingale.
Ph. turdoides, Blyth.	Thrush Nightingale.
Calliope Lathamii.	Gorget Warbler.
Curruca Orphea.	Orpheus Warbler.
C. atricapilla, Bechst.	Black-cap.
C. hortensis, Bechst.	Garden Warbler.
C. Rupellii.	Ruppell's Warbler.
C. melanocephala, Lath.	Sardinian Warbler.
C. leucopogon.	Sub-alpine Warbler.
C. cinerea, Bechst.	Common White-throat.
C. garrula, Bechst.	Lesser White-throat.
C. conspicillata.	Spectacle Warbler.
C. sarda.	Marmora's Warbler.
C. nisoria.	Barred Warbler.
Melizophilus provincialis, Leach.	Dartford Warbler.
Troglodytes Europæus, Cuv.	Wren.
Sylvia trochilus, Gmel.	Willow Wren.
S. rufa, Lath.	Chiff-Chaff.
S. sibilatrix, Bechst.	Wood Wren.
S. icterina, Vieill.	Yellow Willow Wren.
S. hippolais, Temm.	Melodious Willow Wren.
S. Nattereri, Temm.	Natterer's Warbler.
Anthus Richardi, Vieill.	Richard's Pipit.
A. pratensis, Bechst.	Meadow Pipit.
A. rufescens, Temm.	Tawny Pipit.
A. aquaticus, Bechst.	Rock or Shore Pipit.
A. arboreus, Bechst.	Tree Pipit.
A. rufogularis, Temm.	Red-throated Pipit.
Motacilla Yarrellii.	Pied Wagtail.
M. lugubris, Pall.	White-winged Wagtail
M. alba, Linn.	White Wagtail.
M. neglecta, Gould.	Gray-headed Wagtail.
M. boarula, Lath.	Gray Wagtail.
Regulus ignicapillus, Cuv.	Fire-crested Wren.
R. vulgaris, Cuv.	Golden-crested Wren.
R. modestus.	Dalmatian Regulus.
Parus major, Linn.	Great Tit.
P. lugubris, Natt.	Sombre Tit.
P. Sibericus, Gmel.	Siberian Tit.
P. bicolor, Linn.	Toupet Tit.

[1] Including the SCANSORES of the preceding Treatise.

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Parus cyanus, Pall.	Azure Tit.
P. cæruleus, Linn.	Blue Tit.
P. ater, Linn.	Cole Tit.
P. palustris, Linn.	Marsh Tit.
P. cristatus, Linn.	Crested Tit.
P. caudatus, Linn.	Long-tailed Tit.
Calamophilus biarmicus, Leach.	Bearded Tit, or Reed Bird.
Œgithalus pendulinus, Vig.	Penduline Tit.
Bombycivora garrula, Temm.	Waxen Chatterer.
Alauda tartarica, Pall.	
A. calandra, Pall.	Calandra Lark.
A. brachydactyla, Temm.	Short-toed Lark.
A. alpestris, Linn.	Shore-Lark.
A. cristata, Linn.	Crested Lark.
A. arvensis, Linn.	Sky-Lark.
A. arborea, Linn.	Wood-Lark.
Certhilauda bifasciata.	Bifasciated Lark.
Plectrophanes Lapponica, Selb.	Lark-heeled Bunting.
Pl. nivalis, Meyer.	Snow-Bunting.
Emberiza miliaria, Linn.	Common Bunting.
E. melanocephala, Scop.	Black-headed Bunting.
E. citrinella, Linn.	Yellow Bunting.
E. aureola, Pall.	Yellow-breasted Bunting.
E. cirlus, Linn.	Cirl Bunting.
E. hortulana, Linn.	Ortolan Bunting.
E. rustica, Pall.	Rustic Bunting.
E. lesbia.	Lesbian Bunting.
E. cia, Linn.	Meadow-Bunting.
E. pithyornus, Pall.	Pine-Bunting.
E. cæsia, Cretz.	Cretzschmar's Bunting.
E. palustris, Savi.	Marsh-Bunting.
E. schœniculus, Linn.	Reed-Bunting.
Pyrgita domestica, Cuv.	Common Sparrow.
P. montana, Cuv.	Tree-Sparrow.
P. Hispaniolensis, Cuv.	Spanish Sparrow.
P. cisalpina, Cuv.	Alpine Sparrow.
P. petronia.	Doubtful Sparrow.
Fringilla cœlebs, Linn.	Chaffinch.
F. montifringilla, Linn.	Mountain or Bramble Finch.
F. nivalis, Linn.	Snow-Finch.
F. ? hyemalis.	Winter-Finch.
Linaria cannabina, Swains.	Common or Brown Linnet.
L. montana, Ray.	Mountain Linnet or Twite.
L. canescens.	Mealy Redpole.
L. minor, Ray.	Lesser Redpole.
Serinus flavescens.	Serin Finch.
Carduelis elegans, Steph.	Goldfinch.
C. spinus, Steph.	Siskin or Aberdevine.
C. citrinella.	Citril Finch.
Coccothraustes vulgaris, Briss.	Hawfinch.
C. chloris, Flem.	Green Grosbeak.
Loxia pityopsittacus, Bechst.	Parrot Crossbill.
L. curvirostra, Linn.	Common Crossbill.
L. leucoptera, Gmel.	White-winged Crossbill.
Corythus enucleator, Cuv.	Pine Grosbeak.
C. longicauda.	Siberian Grosbeak.
Erythrospiza erythrina, Bon.	Scarlet Grosbeak.
E. rosea.	Rosy Grosbeak.
E. githaginea.	Vinous Grosbeak.
Pyrrhula vulgaris, Temm.	Bullfinch.
Sturnus vulgaris, Linn.	Starling.
S. unicolor, Marm.	Sardinian Starling.
Pastor roseus, Temm.	Rose-coloured Pastor.
Nucifraga caryocatactes, Briss.	Nut-cracker.
Garrulus glandarius, Briss.	Jay.
G. infaustus, Temm.	Siberian Jay.
Pica caudata, Ray.	Magpie.
P. cyanea, Wagl.	Azure-winged Magpie.
Pyrrhocorax Pyrrhocorax, Temm.	Alpine Chough.
Fregilus graculus, Cuv.	Chough.
Corvus corax, Linn.	Raven.
C. corone, Linn.	Carrion Crow.
C. cornix, Linn.	Hooded Crow.
C. monedula, Linn.	Jackdaw.
C. frugilegus, Linn.	Rook.
Picus martius, Linn.	Great Black Woodpecker.
P. viridis, Linn.	Green Woodpecker.
P. canus, Gmel.	Gray-headed Green Woodpecker.
P. leuconotus, Bechst.	White-rumped Woodpecker.
P. major, Linn.	Great Spotted Woodpecker.
P. medius, Linn.	Middle Spotted Woodpecker.
P. minor, Linn.	Lesser Spotted Woodpecker.
Apternus tridactylus, Swains.	Three-toed Woodpecker.
Yunx torquilla, Linn.	Wryneck.
Sitta Europœa, Linn.	Common Nuthatch.
S. Syriaca, Ehrenb.	Dalmatian Nuthatch.
S. Asiatica, Temm.	Asiatic Nuthatch.
Certhia familiaris, Linn.	Common Creeper.
Upupa epops, Linn.	Hoopoe.
Tichodroma phœnicoptera, Temm.	Wall-Creeper.
Cuculus canorus, Linn.	Common Cuckoo.
C. glandarius, Linn.	Great Spotted Cuckoo.
Coccyzus Americanus, Vieill.	American Cuckoo.

Order III.—Rasores.

Columba palumbus, Linn.	Wood-Pigeon.
C. Œnas, Linn.	Stock-Dove.
C. livia, Linn.	Rock-Dove.
C. turtur, Linn.	Turtle-Dove.
Phasianus colchichus, Linn.	Common Pheasant.
Tetrao urogallus, Linn.	Capercailzie, or Cock of the Wood.
T. hybridus, Sparrm.	Hybrid Grouse.
T. tetrix, Linn.	Black Grouse.
Bonasia Europæa.	Hazel Grouse, or Gelinotte.
Lagopus Scoticus, Lath.	Red Grouse.
L. mutus, Leach.	Common Ptarmigan.
L. rupestris, Leach.	Rock Ptarmigan.
L. saliceti, Swains.	Willow Ptarmigan.
L. brachydactylus.	Short-toed Ptarmigan.
Pterocles arenarius, Temm.	Sand-Grouse.
P. setarius, Temm.	Pin-tailed Sand Grouse.
Francolinus vulgaris, Briss.	European Francolin.
Perdix rubra, Ray.	Red-legged Partridge.
P. petrosa, Lath.	Barbary Partridge.
P. saxatilis, Meyer.	Greek Partridge.
P. cinerea, Lath.	Common Partridge.
Coturnix dactylisonans, Meyer.	Quail.
Hemipodius tachydromus, Temm.	Andalusian Turnix.
Glareola torquata, Briss.	Collared Pratincole.
Cursorius Isabellinus, Meyer.	Cream-coloured Courser.
Otis tarda, Linn.	Great Bustard.
O. houbara, Linn.	Ruffed Bustard.
O. tetrax.	Little Bustard.

Order IV.—Grallatores.

Grus cinerea, Bechst.	Common Crane.
G. leucogeranus, Temm.	White Crane.
Anthropoides virgo, Vieill.	Numidian Demoiselle.
Ardea cinerea, Lath.	Common Heron.

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Ardea purpurea, Linn.	Purple Heron.
A. comata, Pall.	Squacco Heron.
A. alba, Linn.	Great Egret.
A. garzetta, Linn.	Little Egret.
A. russata, Wagl.	Rufous-backed Egret.
Nycticorax Europæus, Steph.	Common Night-Heron.
Botaurus stellaris, Steph.	Common Bittern.
B. lentiginosus, Steph.	Freckled Bittern.
B. minutus, Selby.	Little Bittern.
Ciconia alba, Bellon.	White Stork.
C. nigra, Bellon.	Black Stork.
C. Maquari, Temm.	Maquari Stork.
Platalea leucorodia, Linn.	Spoonbill.
Phœnicopterus ruber, Linn.	Common Flamingo.
Œdicnemus crepitans, Temm.	Thick-kneed Bustard.
Himantopus melanopterus, Meyer.	Long-legged Plover.
Squatarola cinerea, Cuv.	Gray Plover.
Vanellus cristatus, Meyer.	Lapwing.
V. Keptuschka, Temm.	Keptuschka Lapwing.
Pluvianus spinosus.	Spur-winged Plover.
Charadrius pluvialis, Linn.	Golden Plover.
C. morinellus, Linn.	Dotterel.
C. hiaticula, Linn.	Ring-Dotterel.
C. minor, Meyer.	Little Ring-Dotterel.
C. Cantianus, Linn.	Kentish Plover.
C. pyrrhothorax, Temm.	Red-chested Dotterel.
Hæmatopus ostralegus, Linn.	Oyster-Catcher.
Ibis Falcinellus, Temm.	Glossy Ibis.
Numenius arquata, Lath.	Common Curlew.
N. Phæopus, Lath.	Whimbrel.
N. tenuirostris, Sav.	Slender-billed Curlew.
Limosa melanura, Leisl.	Black-tailed Godwit.
L. rufa, Briss.	Bar-tailed Godwit.
L. terek, Temm.	Terek Godwit.
Recurvirostra Avocetta, Linn.	Avocet.
Totanus fuscus, Leisl.	Spotted Redshank.
T. calidris, Bechst.	Redshank.
T. semipalmatus, Temm.	Semipalmated Sandpiper.
T. glottis, Bechst.	Greenshank.
T. Bartramius, Temm.	Bartram's Sandpiper.
T. stagnatilis, Bechst.	Marsh Sandpiper.
T. ochropus, Temm.	Green Sandpiper.
T. glareola, Temm.	Wood Sandpiper.
T. hypoleucus, Temm.	Common Sandpiper.
T. macularius, Temm.	Spotted Sandpiper.
Strepsilas collaris, Temm.	Turnstone.
Scolopax rusticola, Linn.	Woodcock.
S. major, Linn.	Great Snipe.
S. Sabini, Vig.	Sabine's Snipe.
S. gallinago, Linn.	Common Snipe.
S. gallinula, Linn.	Jack Snipe.
Macroramphus griseus, Leach.	Gray Snipe.
Calidris canutus, Briss. and Cuv.	Knot.
Machetes pugnax, Cuv.	Ruff.
Tringa rufescens, Vieill.	Buff-breasted Sandpiper.
T. pectoralis, Bonap.	Pectoral Sandpiper.
T. subarquata, Temm.	Pygmy Curlew.
T. variabilis, Meyer.	Dunlin or Purre.
T. Schinzii, Bonap.	Schinz's Sandpiper.
T. platyrhyncha, Temm.	Broad-billed Tringa.
T. minuta, Leisl.	Little Sandpiper.
T. Temminckii, Leisl.	Temminck's Tringa.
T. maritima, Brunn.	Purple Sandpiper.
Arenaria calidris, Meyer.	Sanderling.
Phalaropus hyperboreus, Lath.	Red-necked Phalarope.
Phalaropus platyrhynchus, Temm.	Gray Phalarope.
Fulica atra, Linn.	Coot.
Rallus aquaticus, Linn.	Water-Rail.
Porphyrio hyacinthinus, Tem.	Hyacinthine Porphyrio.
Gallinula crex, Lath.	Land-Rail.
G. chloropus, Lath.	Common Gallinule.
Zapornia porzana.	Spotted Crake.
Z. Baillonii, Leach.	Baillon's Crake.
Z. pusilla, Steph.	Little Crake.

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Order V.—Natatores.

Anser hyperboreus, Pall.	Snow-Goose.
A. ferus, Steph.	Gray-Lag Wild Goose.
A. segetum, Steph.	Bean Goose.
A. albifrons, Steph.	White-fronted Goose.
A. leucopsis, Bechst.	Bernicle Goose.
A. ruficollis, Pall.	Red-breasted Goose.
A. brenta, Flem.	Brent Goose.
Chenalopex Ægyptiaca, Steph.	Egyptian Goose.
Cygnus mansuetus, Gmel.	Domestic Swan.
C. ferus, Ray.	Whistling Swan or Hooper.
C. Bewickii, Yarr.	Bewick's Swan.
Tadorna vulpanser, Flem.	Common Shieldrake.
T. rutila, Steph.	Ruddy Shieldrake.
Mareca Penelope, Selby.	Wigeon.
Rhynchaspis clypeata, Steph.	Shoveller Duck.
Anas Boschas, Linn.	Common Wild Duck.
Querquedula Crecca, Steph.	Common Teal.
Q. glocitans, Vig.	Bimaculated Teal.
Q. circia, Steph.	Gargany Teal.
Dafila caudacuta, Leach.	Pin-tail Duck.
Chauliodes strepera, Swains.	Gadwall.
Fuligula ferina, Steph.	Red-headed Pochard.
F. leucophthalma, Steph.	White-eyed or Castaneous Duck.
F. rufina, Steph.	Red-crested Duck
F. cristata, Steph.	Tufted Duck.
F. marila, Steph.	Scaup Pochard.
F. dispar, Steph.	Western Duck.
F. marmorata.	Marbled Duck.
Somateria mollissima, Leach.	Eider Duck.
S. spectabilis, Leach.	King Duck.
Oidemia perspicillata, Flem.	Surf Scoter.
O. fusca, Flem.	Velvet Scoter.
O. nigra, Flem.	Black Scoter.
Clangula vulgaris, Leach.	Golden Eye.
C. Barrovii, Sw. and Rich.	Barrow's Duck.
C. histrionica, Leach.	Harlequin Duck.
Harelda glacialis, Leach.	Long-tailed Duck.
Undina leucocephala.	White-headed Duck.
Mergus merganser, Linn.	Goosander.
M. serrator, Linn.	Red-breasted Merganser.
M. cucullatus, Linn.	Hooded Merganser.
M. albellus, Linn.	Smew.
Podiceps cristatus, Lath.	Great crested Grebe.
P. rubricollis, Lath.	Red-necked Grebe.
P. cornutus, Lath.	Horned Grebe.
P. auritus, Lath.	Eared Grebe.
P. minor, Lath.	Little Grebe, or Dabchick.
Colymbus glacialis, Linn.	Northern Diver.
C. arcticus, Linn.	Black-throated Diver.
C. septentrionalis, Linn.	Red-throated Diver.
Uria troile, Linn.	Foolish Guillemot.
U. lachrymans, Lapyl.	Bridled Guillemot.
U. Brunnichii, Sab.	Brunnick's Guillemot.
U. grylle, Lath.	Black Guillemot.
Alca impennis, Linn.	Great Auk.

Bibliography.

Alca torda, Linn.	Razor-billed Auk.
Mergulus alle, Bon.	Little Auk.
Mormon fratercula, Temm.	Puffin.
M. glacialis, Leach.	Northern Puffin.
Pelecanus onocrotalus, Linn.	Pelican.
P. crispus, Feld.	Dalmatian Pelican.
Phalacrocorax carbo, Steph.	Common Cormorant.
Ph. graculus, Briss.	Black Cormorant.
Ph. pygæmus, Steph.	Little Cormorant.
Ph. cristatus, Steph. and Flem.	Green Cormorant.
Ph. Desmarestii.	Desmarest's Cormorant.
Sula Bassana, Briss.	Solan Goose.
S. melanura, Temm.	Black-tailed Gannet.
Sterna Caspia, Pall.	Caspian Tern.
S. cantiaca, Gmel.	Sandwich Tern.
S. Anglica, Mont.	Gull-billed Tern.
S. hirundo, Linn.	Common Tern.
S. Dougallii, Mont.	Roseate Tern.
S. minuta, Linn.	Little Tern.
S. stolida.	Noddy Tern.
Viralva nigra, Leach.	Black Tern.
V. leucoptera, Leach.	White-winged Tern.
V. leucopareia, Steph.	Moustache Tern.
Xema ridibunda, Boié.	Laughing Gull.
X. atricilla.	Black-winged Gull.
X. melanocephala, Boié.	Black-headed Gull.
X. minuta, Boié.	Little Gull.
X. Sabinii, Leach.	Sabine's Gull.
Larus marinus, Linn.	Great black-backed Gull.
L. fuscus, Linn.	Lesser black-backed Gull.
L. glaucus, Brunn.	Glaucous Gull.
L. islandicus, Edm.	Iceland Gull.
L. argentatus, Brunn.	Herring Gull.
L. rissa, Linn.	Kittiwake Gull.
L. eburneus, Gmel.	Ivory Gull.
L. canus, Linn.	Common Gull.
L. Audouinii, Temm.	Audouin's Gull.
Lestris catarractes, Temm.	Skua.
L. pomarinus, Temm.	Pomarine Gull.
L. Richardsonii, Swains.	Richardson's Lestris.
L. parasiticus, Ill.	Parasitic Gull.
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Th. pelagica, Selby.	Common Storm-Petrel.
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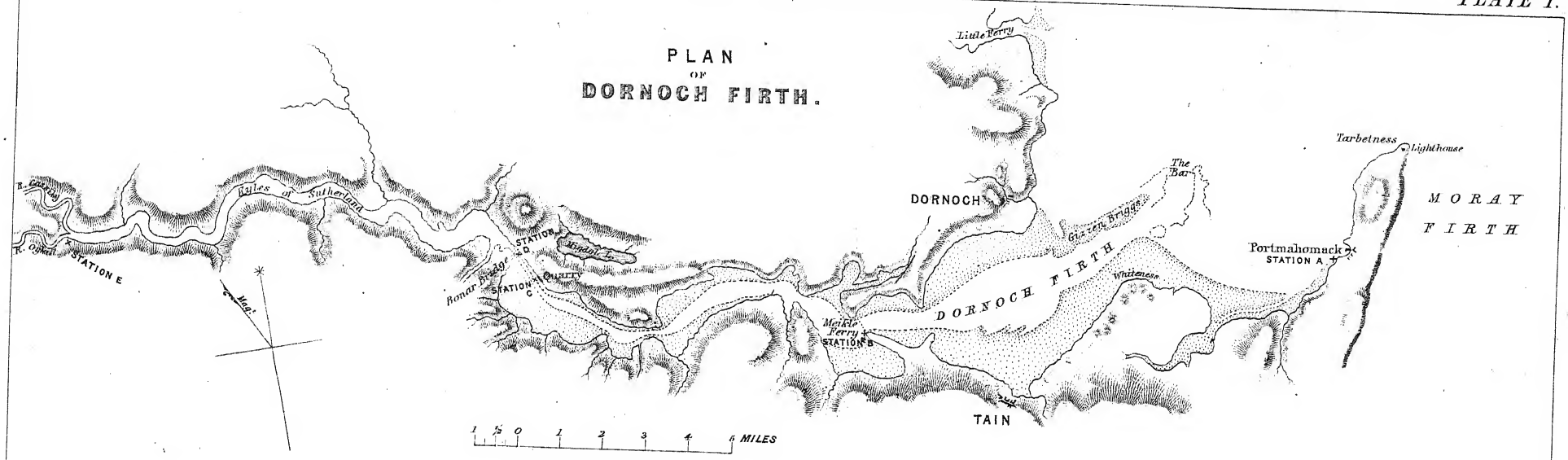
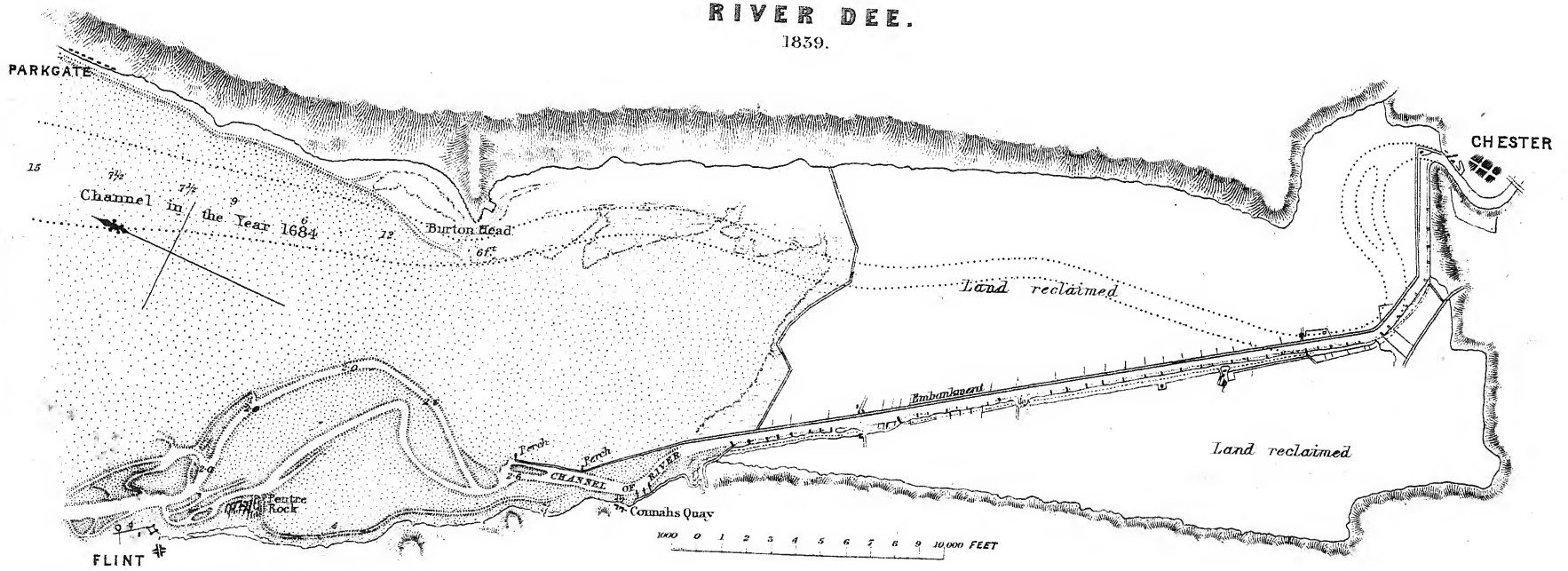
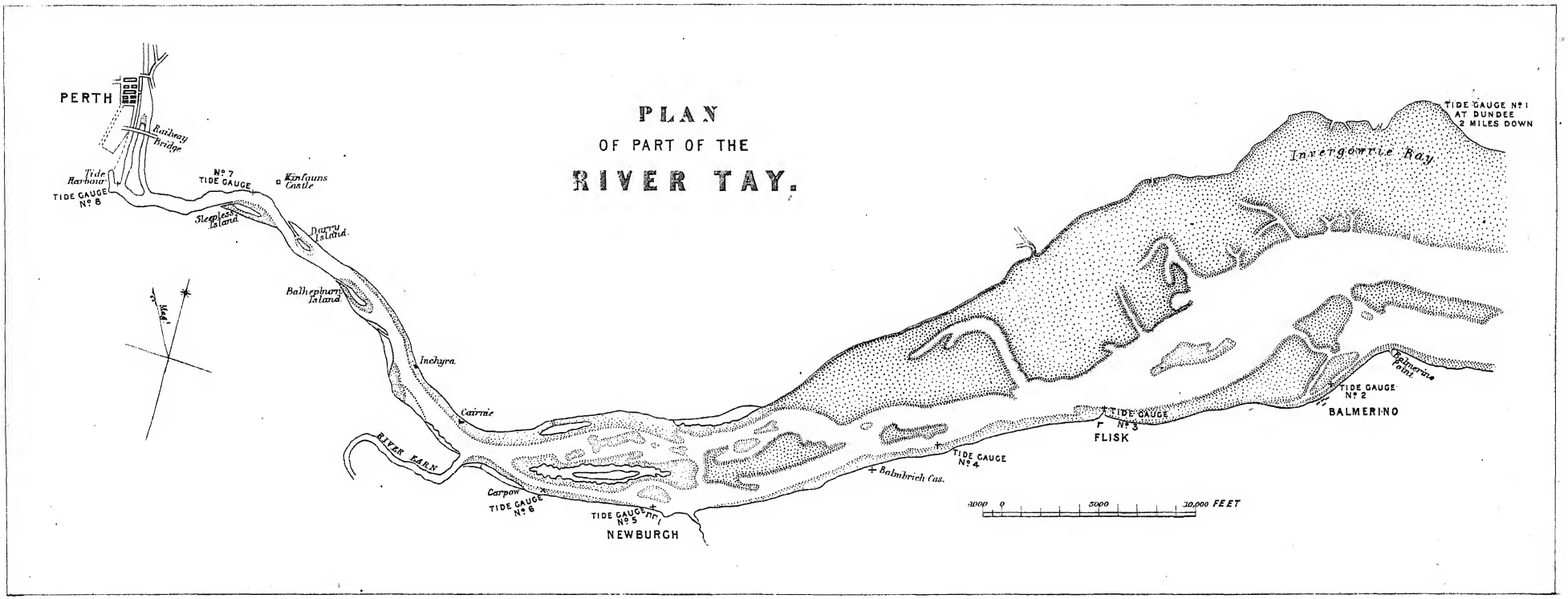
PLAN
OF
DORNOCH FIRTH.

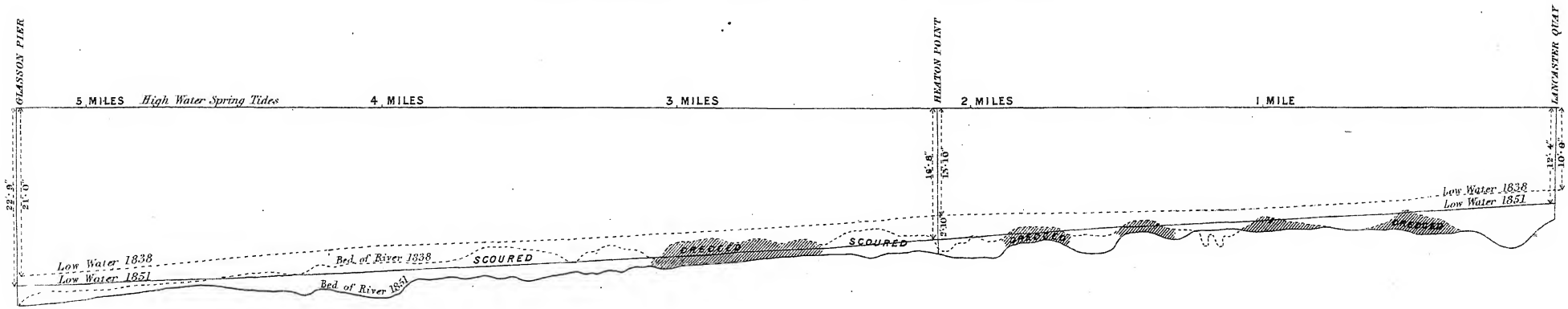


PLAN
OF PART OF THE
RIVER DEE.
1839.

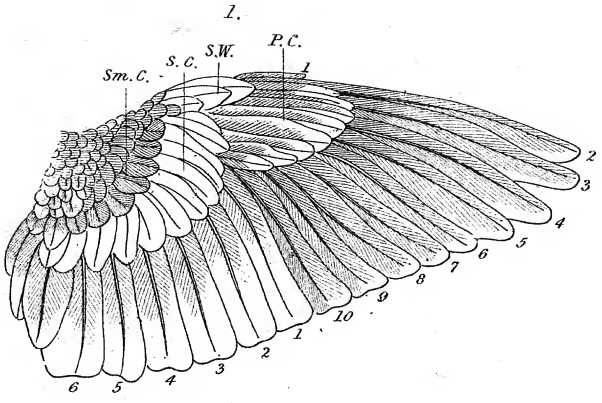




LONGITUDINAL SECTION OF PART OF RIVER LUNE.



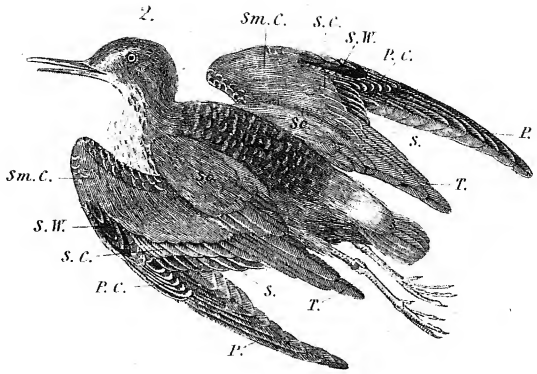
1.



Wing of Starling_Sturnus vulgaris.

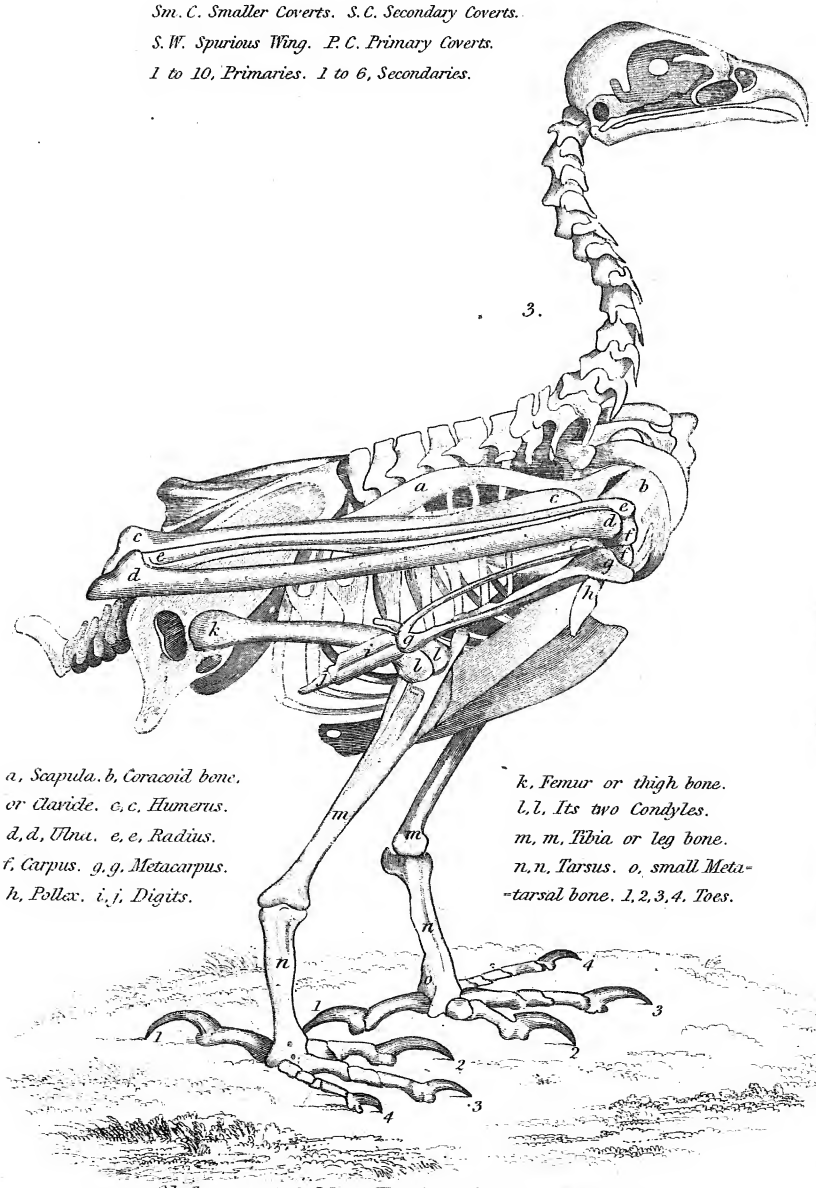
Sm. C. Smaller Coverts. S. C. Secondary Coverts.
S. W. Spurious Wing. P. C. Primary Coverts.
1 to 10, Primaries. 1 to 6, Secondaries.

2.



Sc. Scapulars. Sm. C. Smaller Coverts.
S. W. Spurious Wing. S. C. Secondary Coverts.
P. C. Primary Coverts. P. Primaries.
S. Secondaries. T. Tertials.

3.

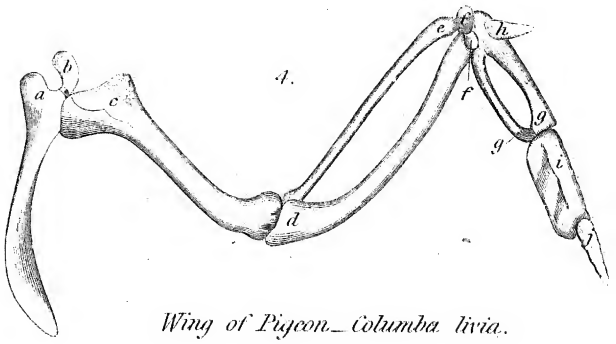


a, Scapula. b, Coracoid bone, or Clavicle. c, c. Humerus. d, d, Ulna. e, e, Radius. f, Carpus. g, g. Metacarpus. h, Pollex. i, j, Digits.

k, Femur or thigh bone. l, l, Its two Condyles. m, m, Tibia or leg bone. n, n, Tarsus. o, small Meta-tarsal bone. 1, 2, 3, 4. Toes.

Skeleton of Golden Eagle_Aquila chrysaetus.

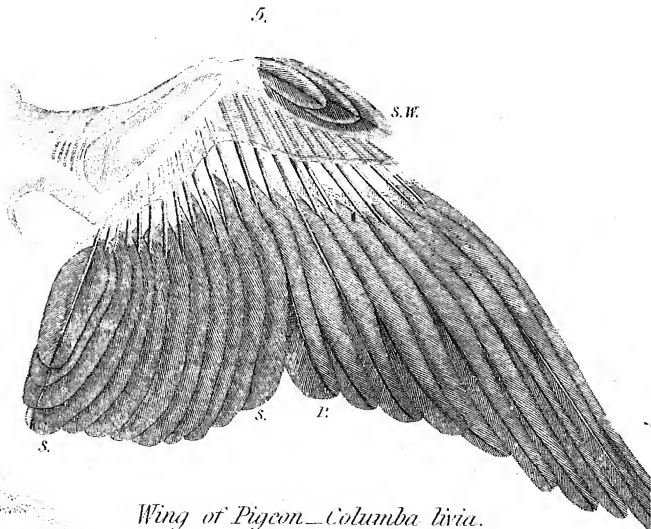
4.



Wing of Pigeon_Columba livia.

a. Scapula. b, tip of Coracoid bone. c, Humerus. d, Ulna. e, Radius. f, f. Carpus. g, g. Metacarpus. h, Pollex. i, j. Digits.

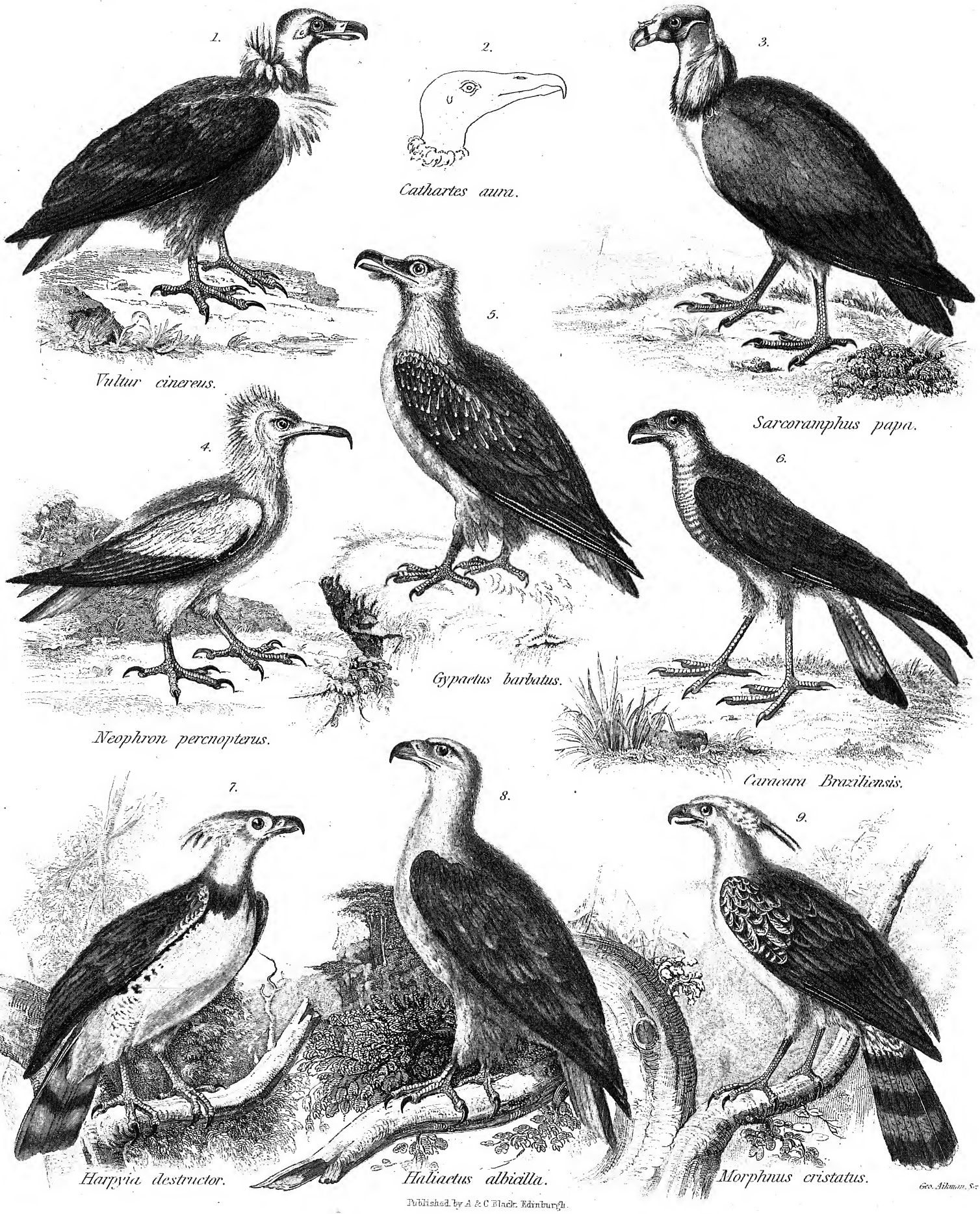
5.



Wing of Pigeon_Columba livia.

S. W. Spurious Wing.
S. S. Secondaries.
P. P. Primaries.

Drawn by W. Macgillivray. Geo. Aikman, Sc.
Published by A. & C. Black Edinburgh.



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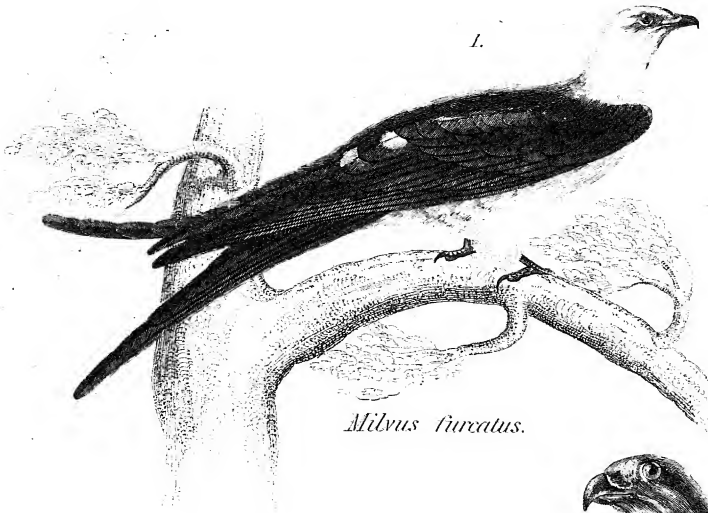
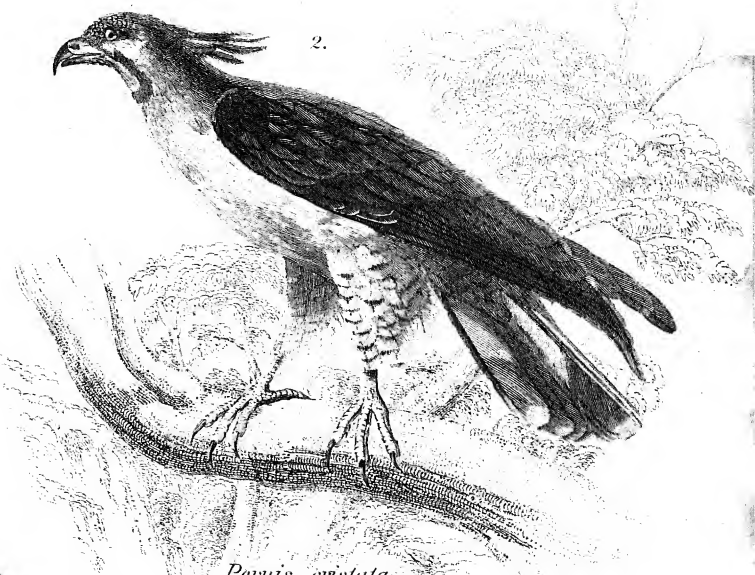


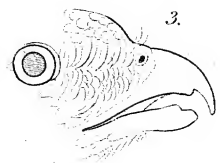
1.

Milvus furcatus.



2.

Pernis cristata.



3.

Head of Falco.

4.

Falco Islandicus.

5.

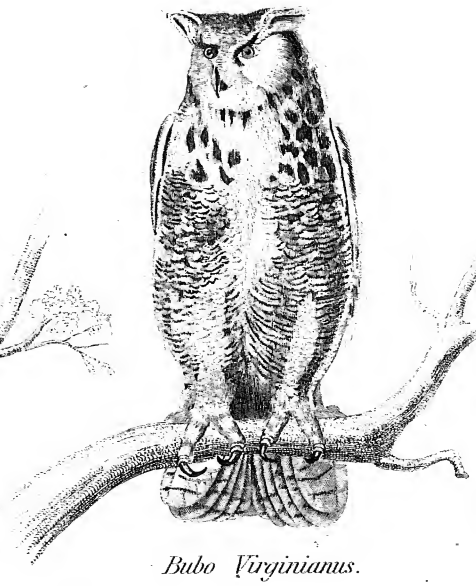
Circus superciliosus.

6.

Syrnium pagodarum.

7.

Scops vulgaris.



8.

Bubo Virginianus.

9.

Gypogeranus serpentarius.

Geo. Aikman, Sculpt.

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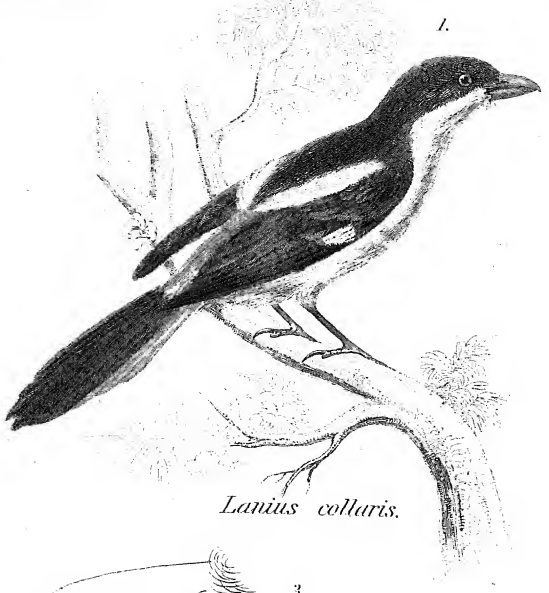
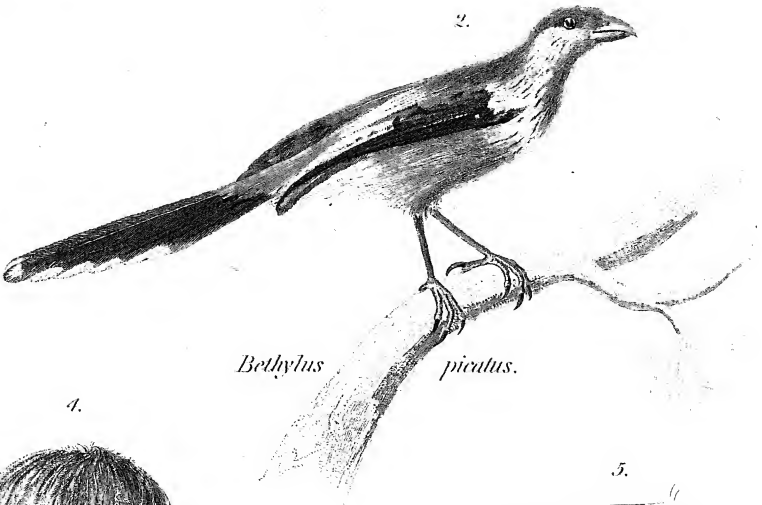


1.

Lanius collaris.



2.

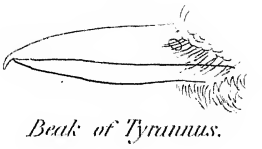
Bethylus picatus.

3.

Beak of Vanga.

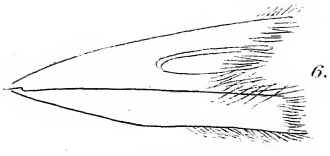
4.

Cephalopterus ornatus.



5.

Beak of Tyrannus.

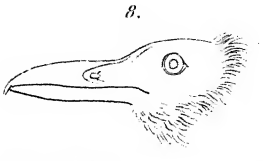


6.

Beak of Chalybaeus.

7.

Edolius remifer.

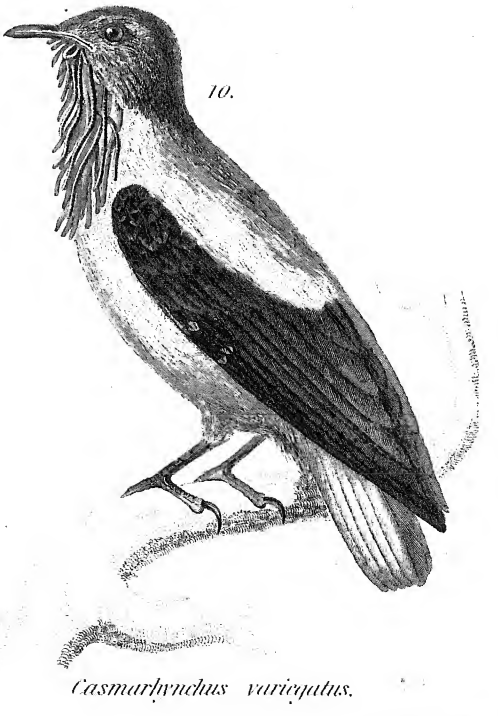


8.

Head of Gymnocephalus.

9.

Tanagra chlorotica.



10.

Casmarhynchus variegatus.

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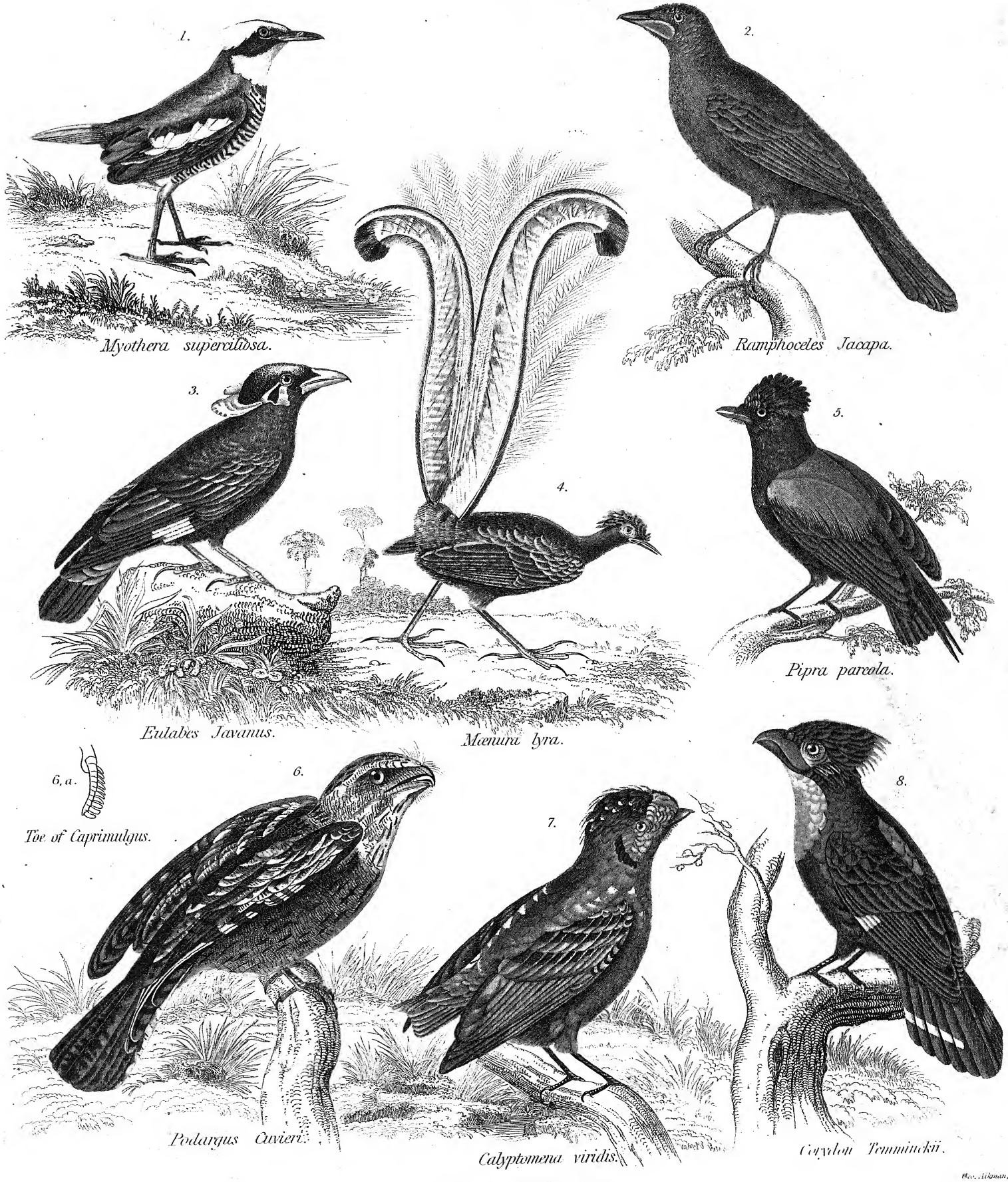
Geo. Aikman, Sculp.



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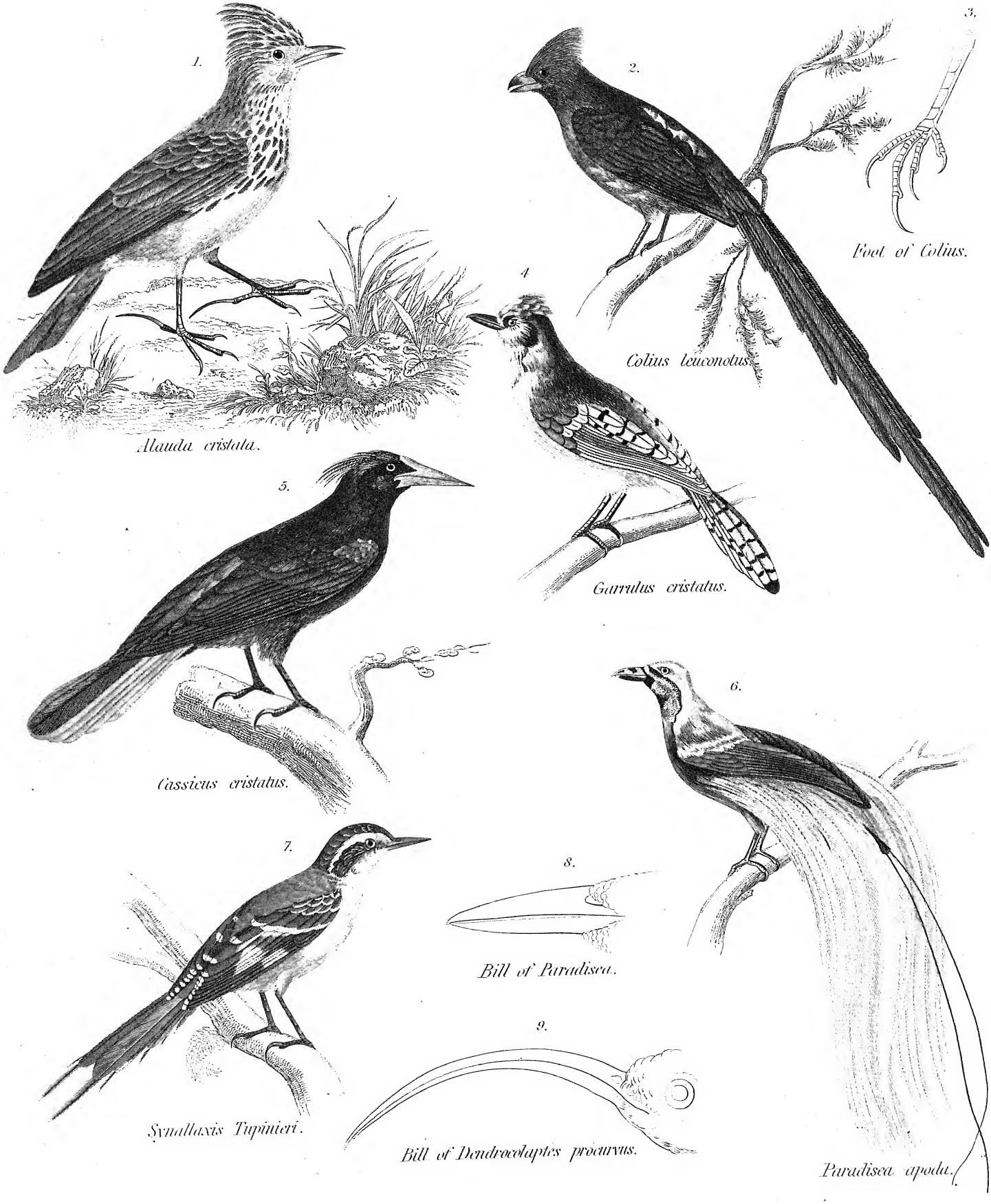
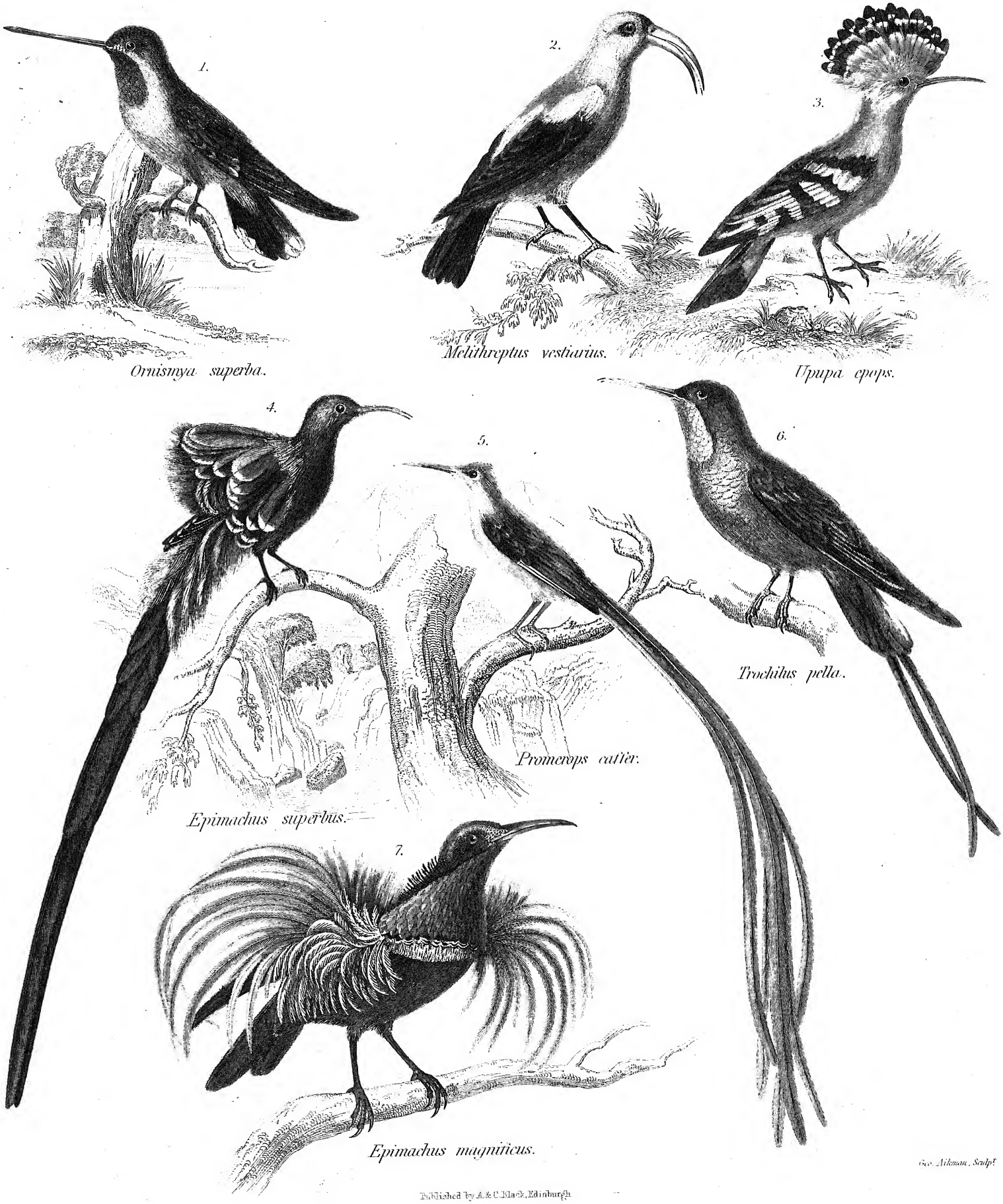


Published by A. & C. Black, Edinburgh.



Ornismya superba.

Melithreptus vestiarius.

Upupa epops.

Epimachus superbus.

Promerops cafler.

Trochilus pella.

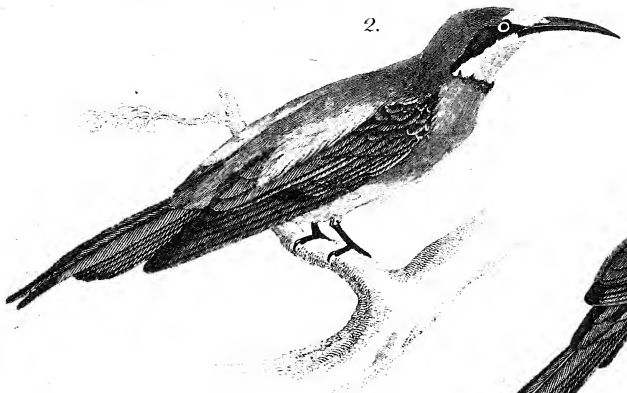
Epimachus magnificus.

Geo. Aikman, Sculpt.

Published by A. & C. Black, Edinburgh.

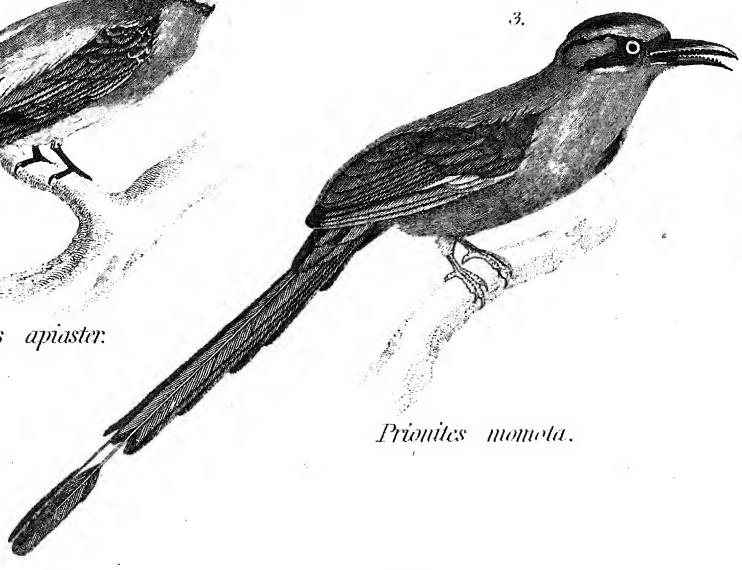
1.

Foot of Alcedo.



2.

Merops apiaster.

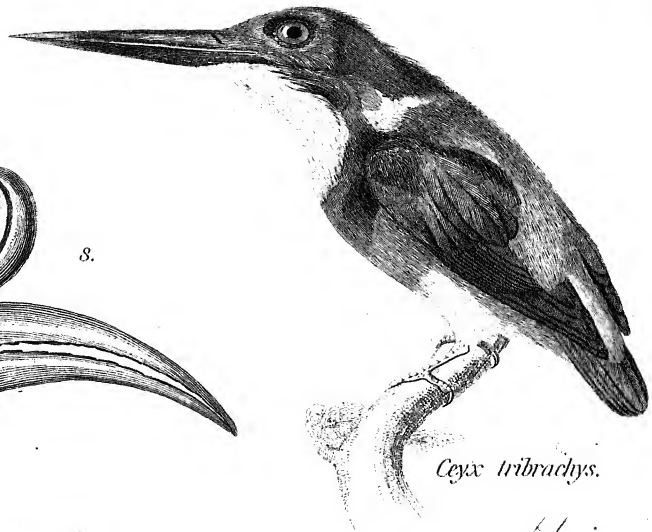


3.

Prionites momota.

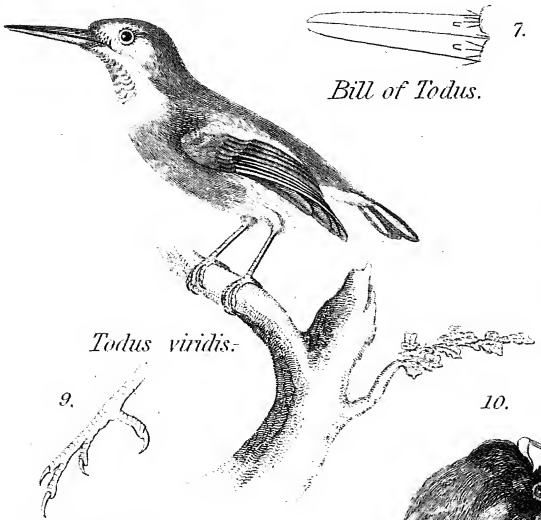
4.

Alcedo cristata.



5.

Ceyx tribrachys.

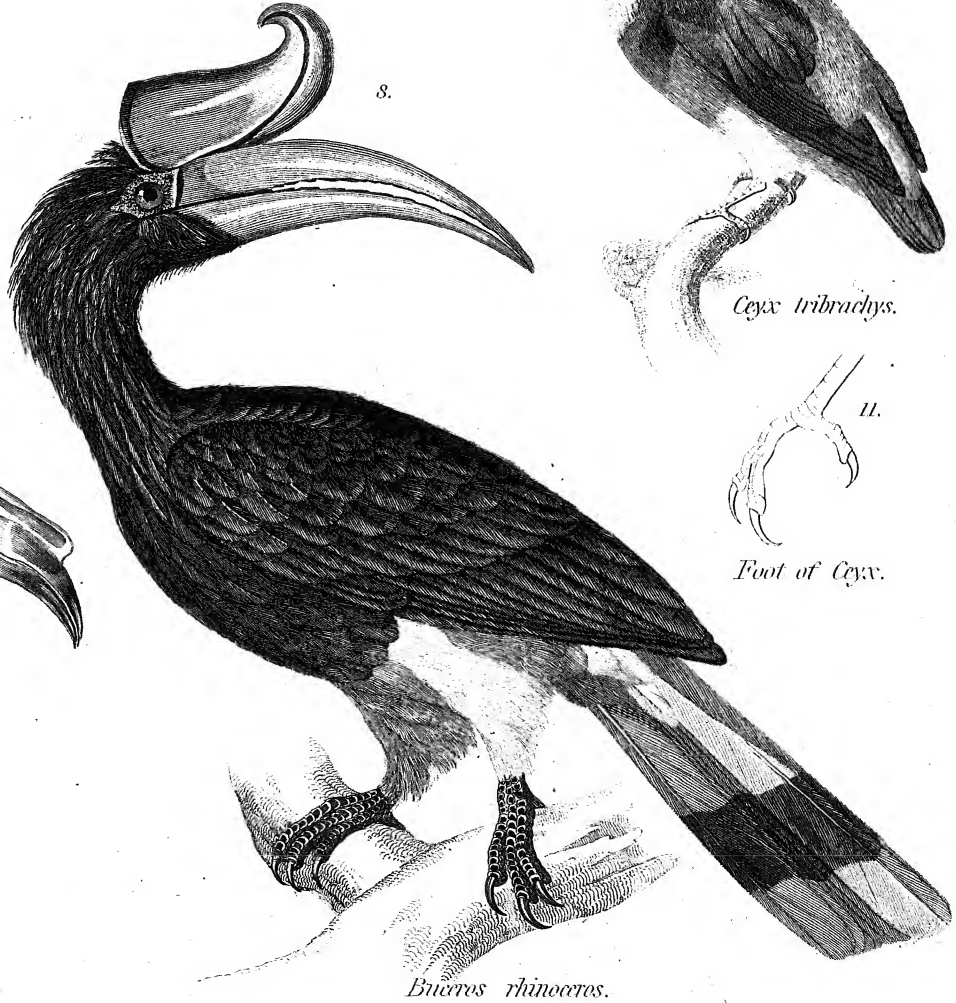


6.

Todus viridis.

7.

Bill of Todus.

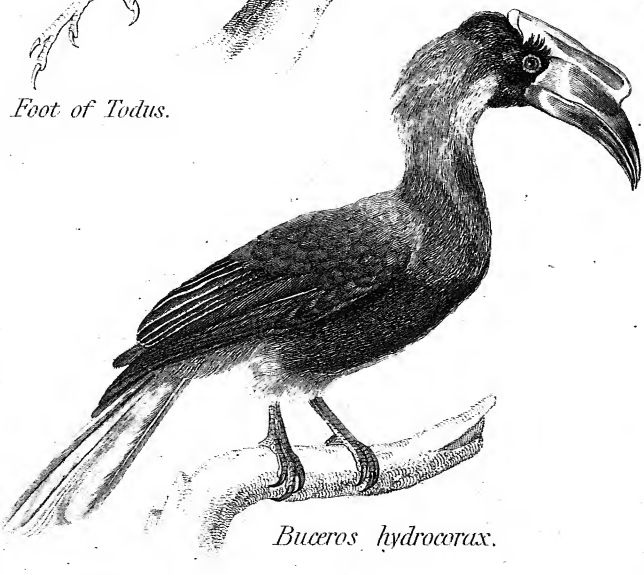


8.

Buceros rhinoceros.

9.

Foot of Todus.



10.

Buceros hydrocorax.

11.

Foot of Ceyx.

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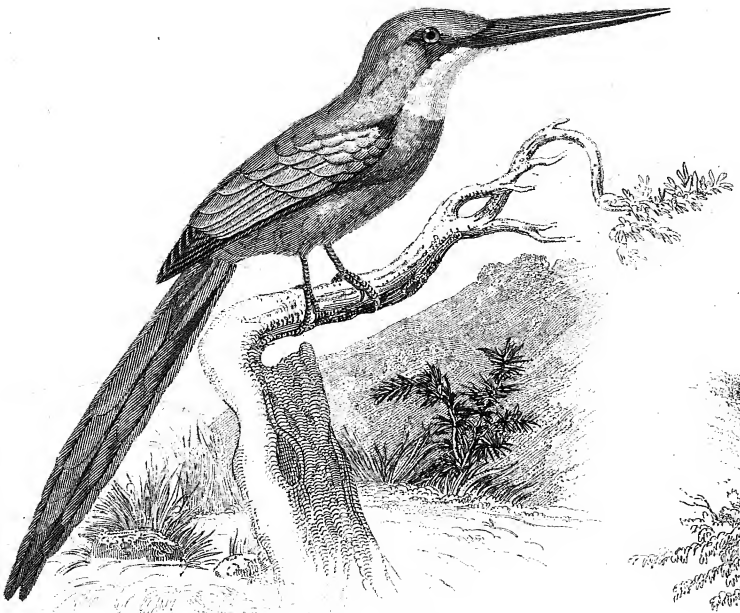
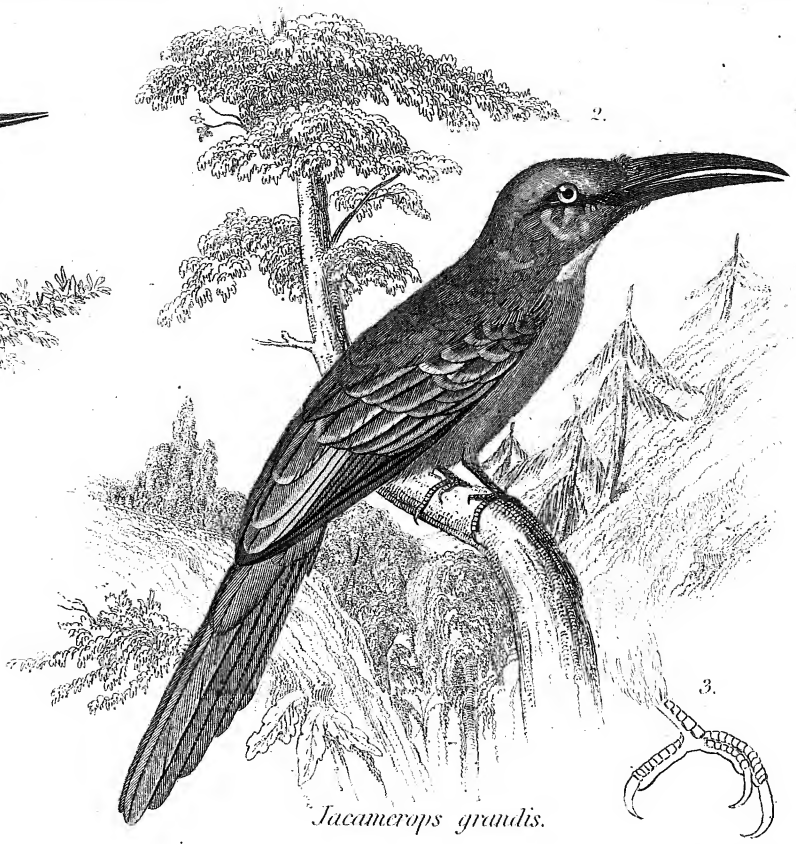
Geo. Aikman, Sc.



Galbula ruficauda.

2.

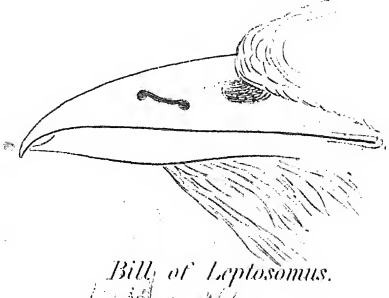


Jacamerops grandis.

3.

Foot of Picoides.

Coccyzus cristatus.

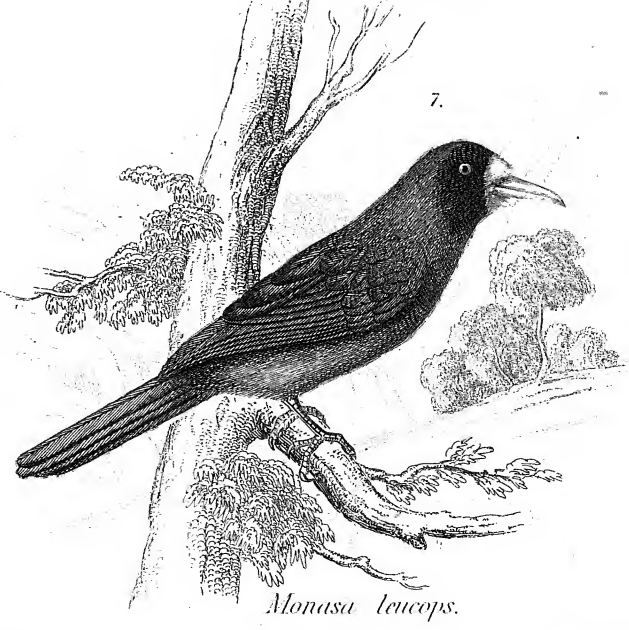


Bill of Leptosomus.

6.

Indicator minor.

7.



Monasa leucops.

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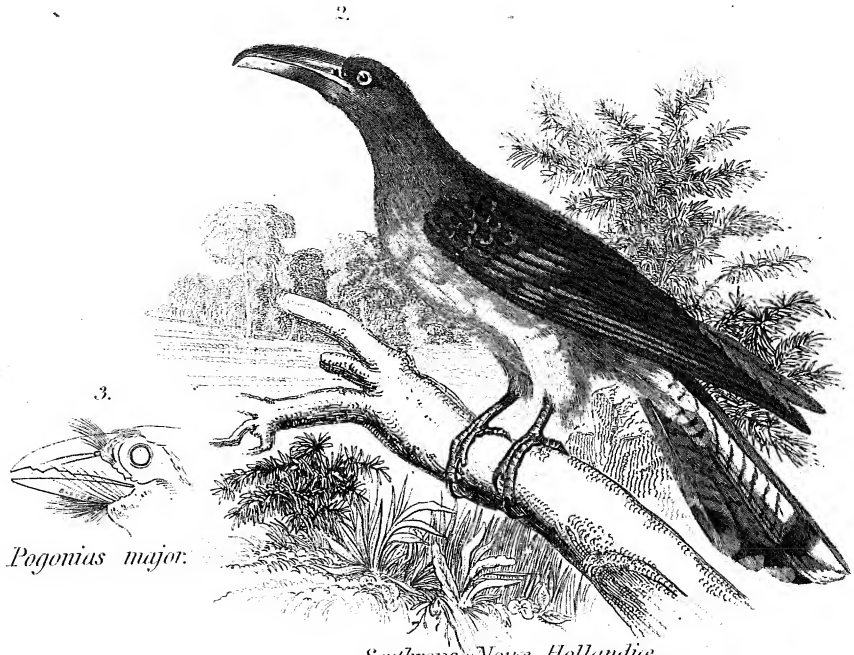
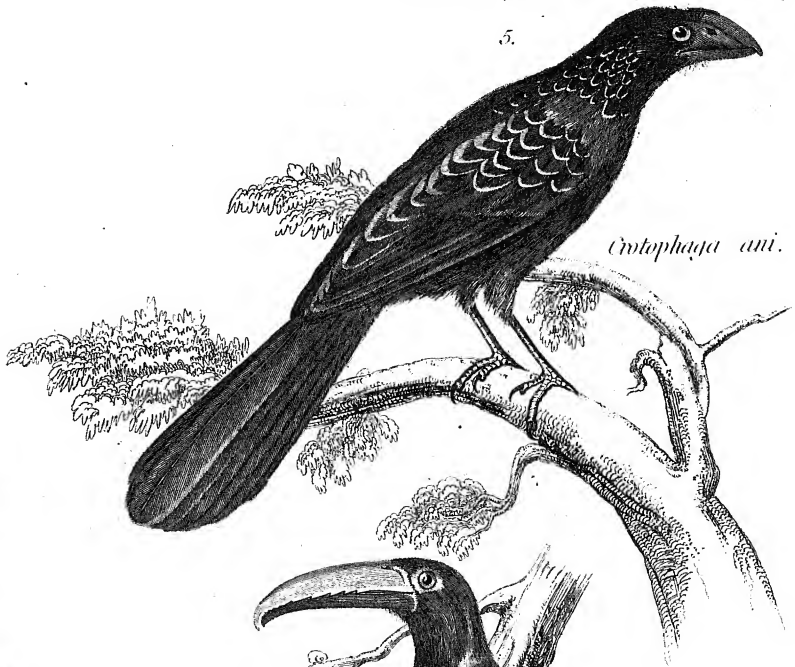
Phœnicophaeus superciliosus.



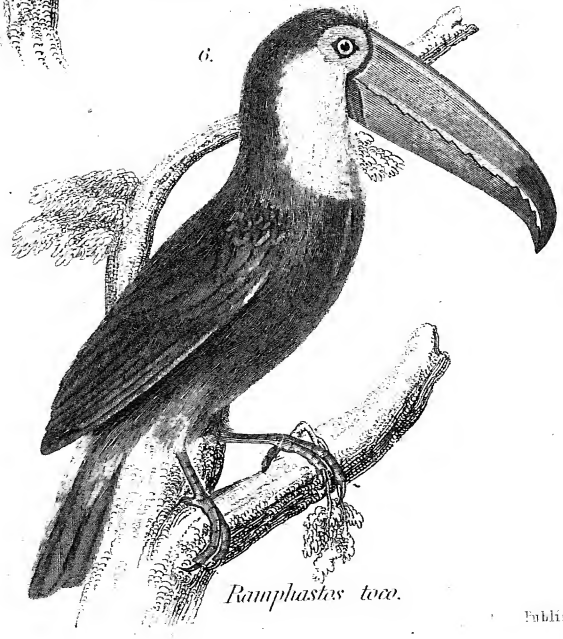
Pogonias major.

Scythrops Novæ Hollandiæ.

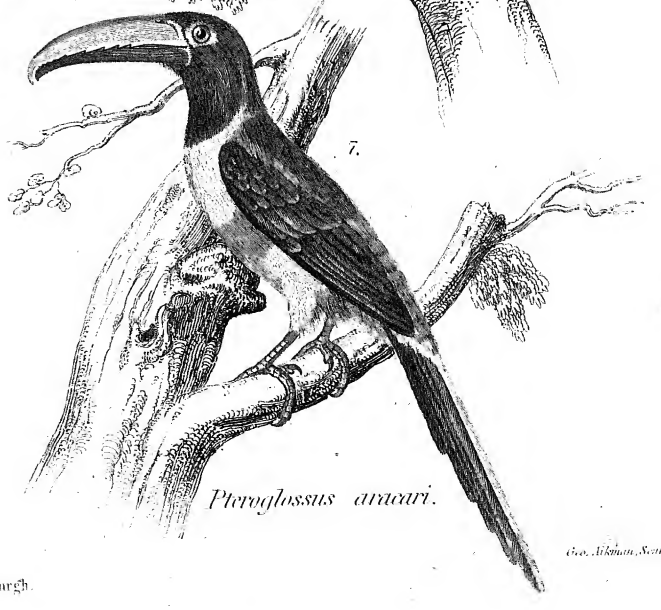
Trogon viridis.



Crotophaga ani.



Ramphastos toco.



Pteroglossus aracari.

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Geo. Aikman, Sculp.

Macrocarus trivolor.

Calyptorhynchus Banksii.

Plyctolophus galeritus.

4.

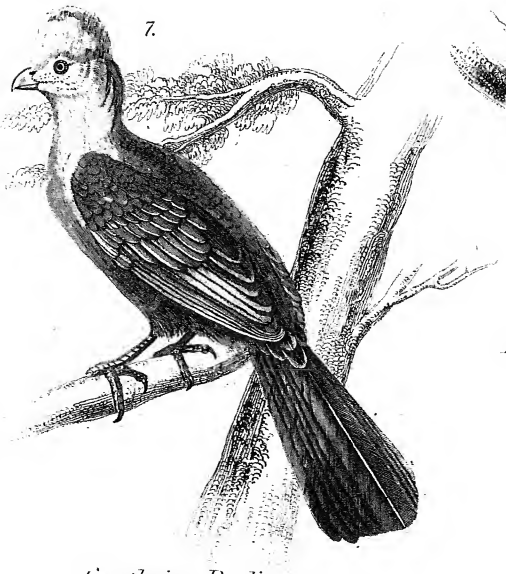
Pezophorus terrestris.

5.

Head of Microglossum.

6.

Microglossum aterrimum.



7.

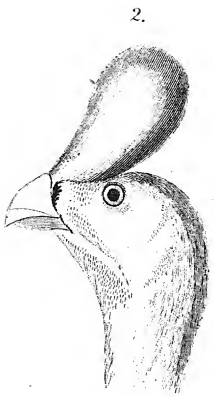
Corythaix Paulina.

Musophaga gigantea.

Published by A. & C. Black, Edinburgh.

Geo. Aikman, Scul.

Crax rubra.



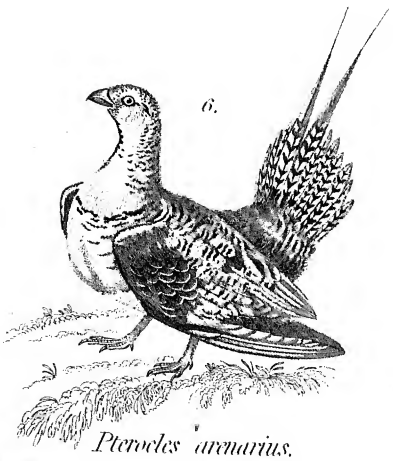
Head of Ourax pauxi.

Gallus Bankiva, Male.

Gallus Bankiva, Female.

Tragopan Satyrus.

Cryptonyx coronatus.



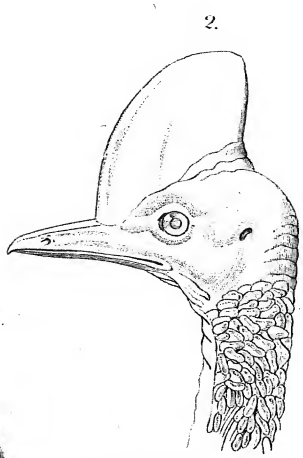
Pterocles arenarius.

Ortyx californica.

Tinamus rufescens.

Ortygis pugnax.

Lophyrus coronatus.



2.

Casuarius galeatus.

3.

Vinago aromatica.

4.

Otis Arabs.

5.

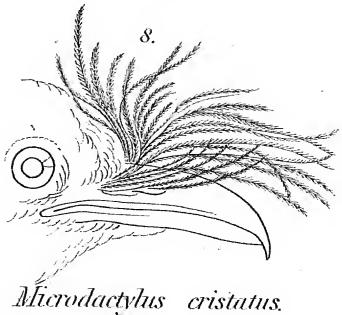
Struthio camelus.

6.

Plumes of the Emeu.

7.

Psophia crepitans.



8.

Microdactylus cristatus.

9.

Anthropoides pavonina.

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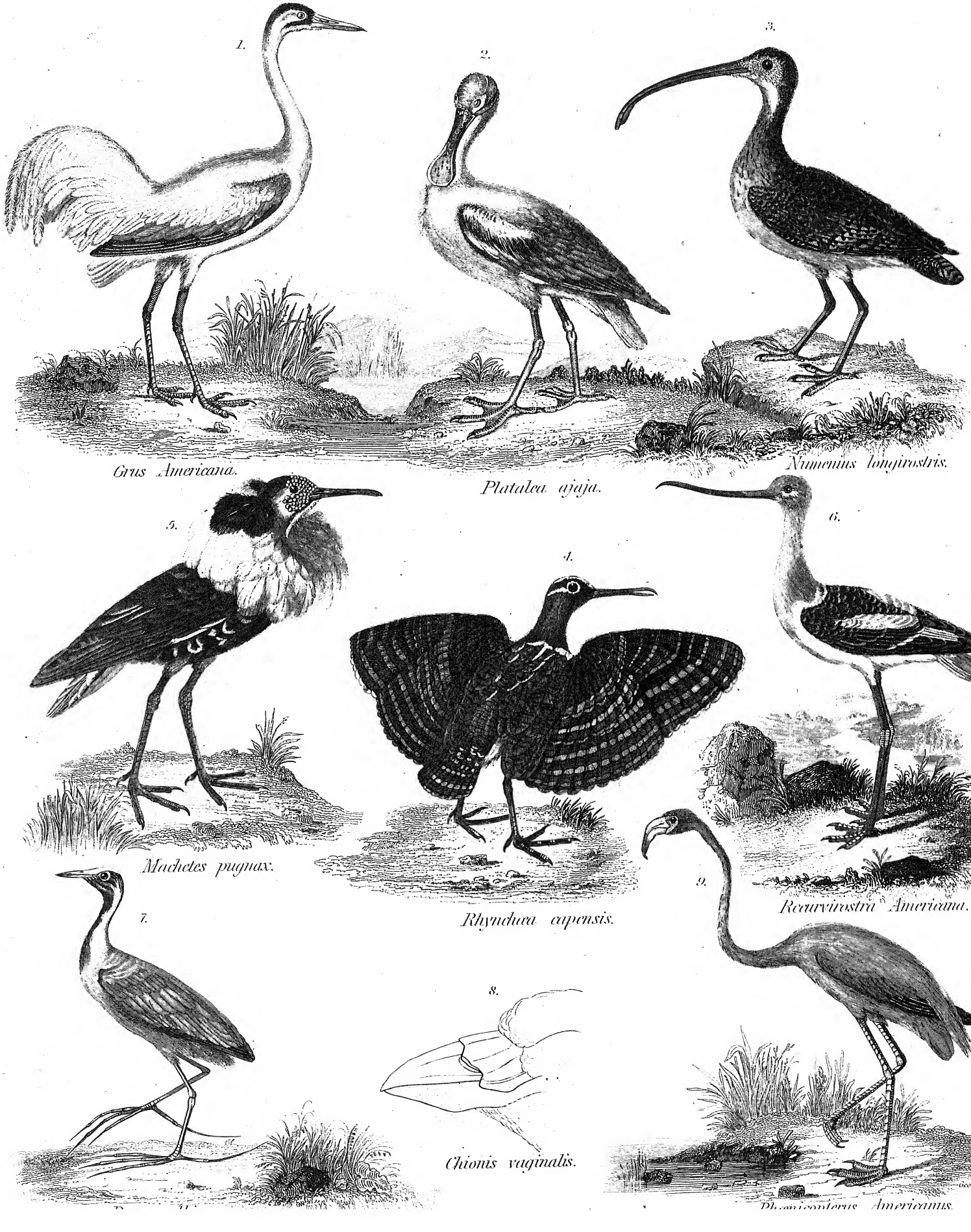
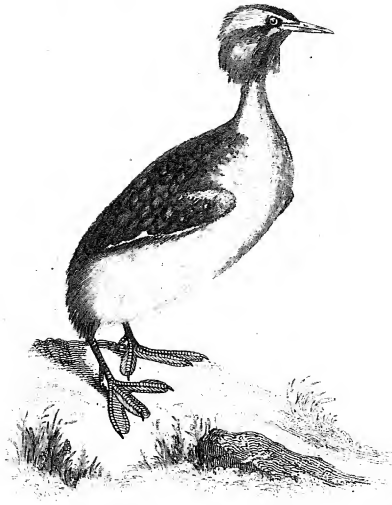
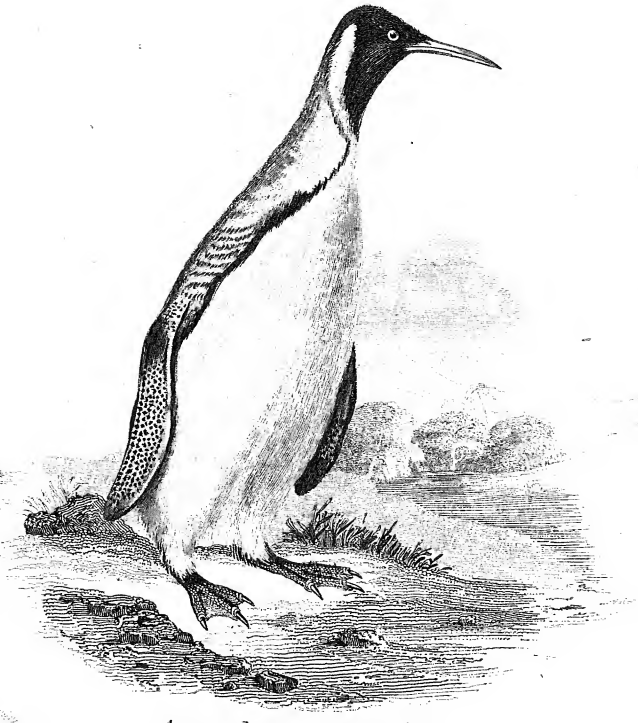
Geo. Aikman, Sculp.

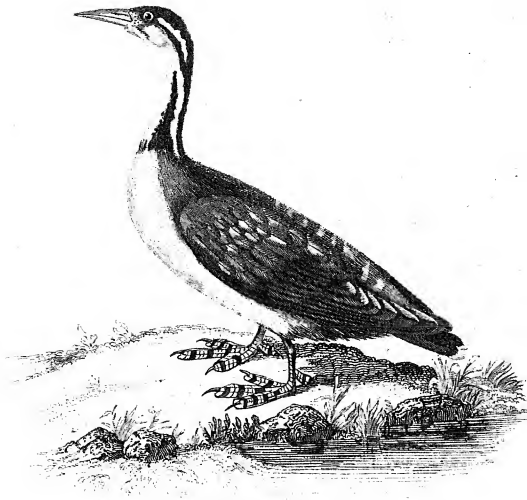

1.
2.
3.
Grus Americana.
Platalea ajaja.
Numenius longirostris.
5.
4.
6.
Machetes pugnax.
Rhynchaea capensis.
Recurvirostra Americana.
7.
8.
9.
Chionis vaginalis.



Podiceps cornutus.

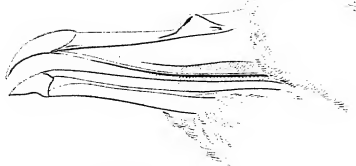


Aptenodytes patagonica.



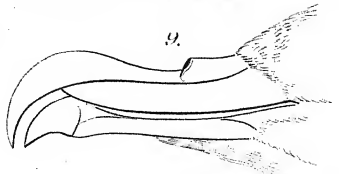
Podoa Surinamensis.

6.



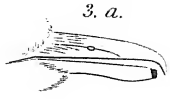
Bill of Pachyptila.

9.



Bill of Puffinus.

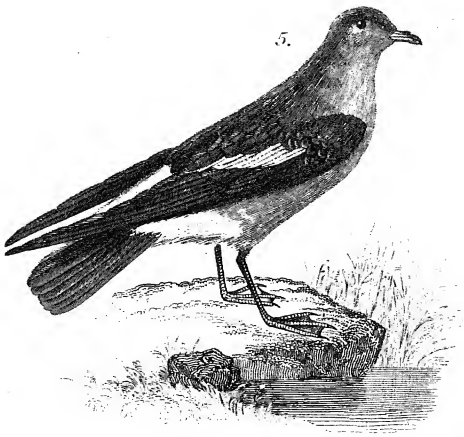
3. a.



3. b.

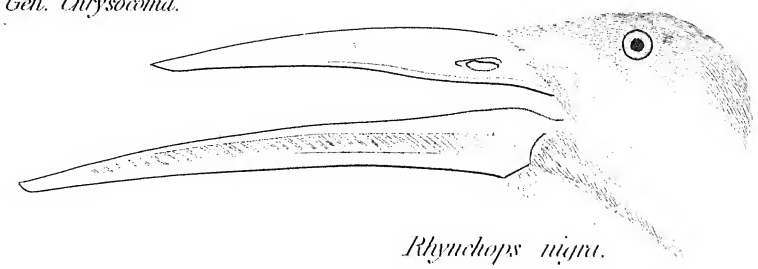
Gen. Spheniscus. Gen. Chrysocoma.

5.



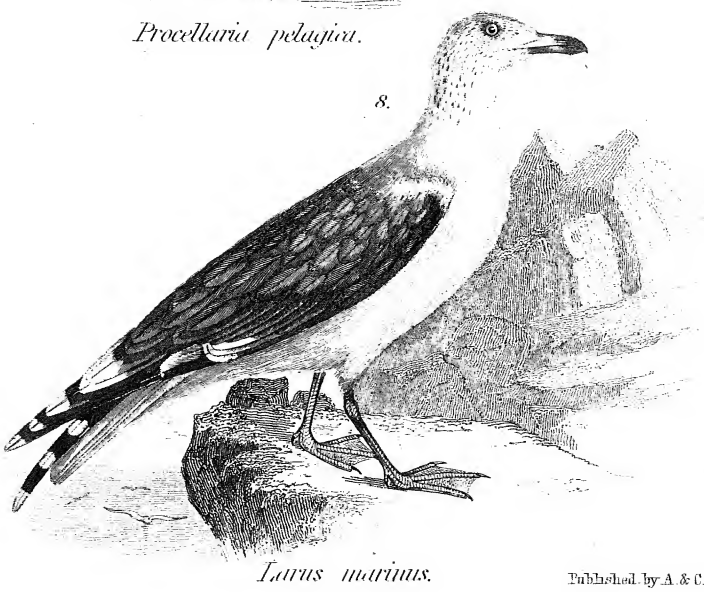
Procellaria pelagica.

7.



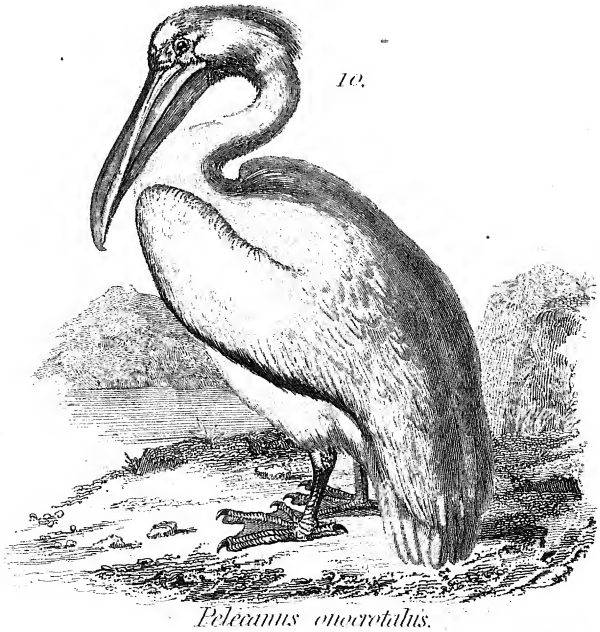
Rhynchops nigra.

8.



Larus marinus.

10.



Pelecanus onocrotalus.

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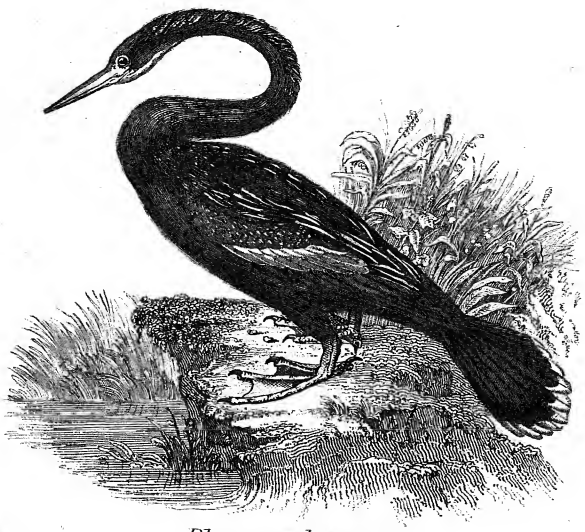
1.



Plotus melanogaster.

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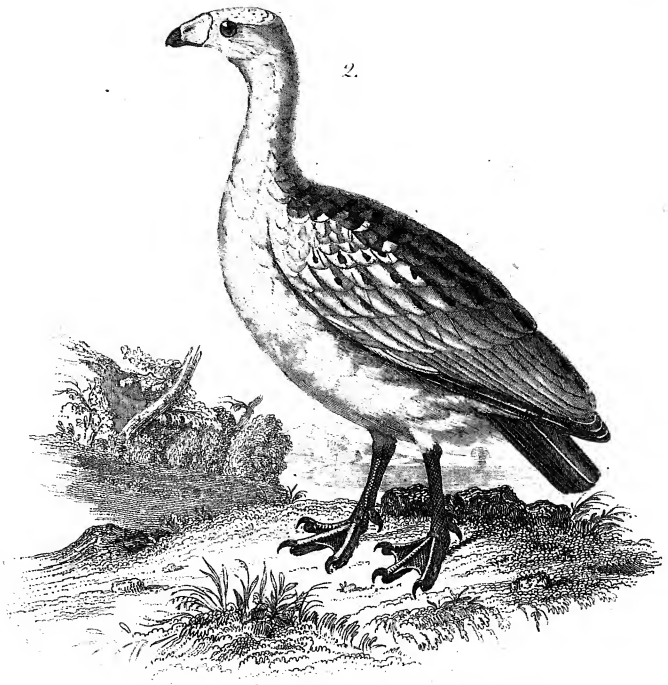
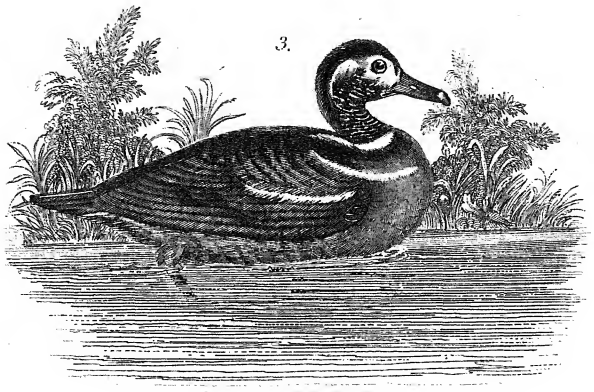


Cereopsis Novæ-Hollandiæ.

3.



Clangula histrionica.

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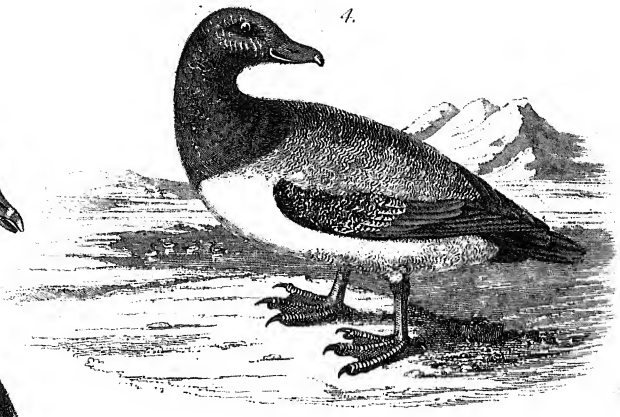
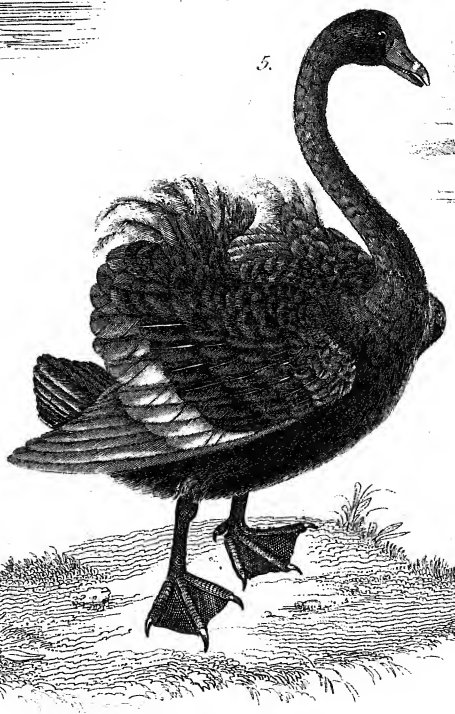


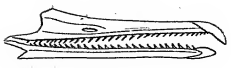
Fuligula Valisnieri.

5.



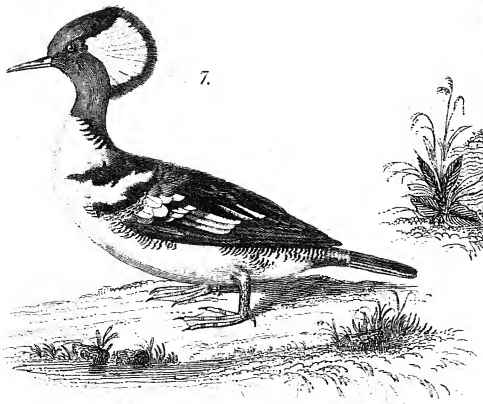
Cygnus atratus.

6.



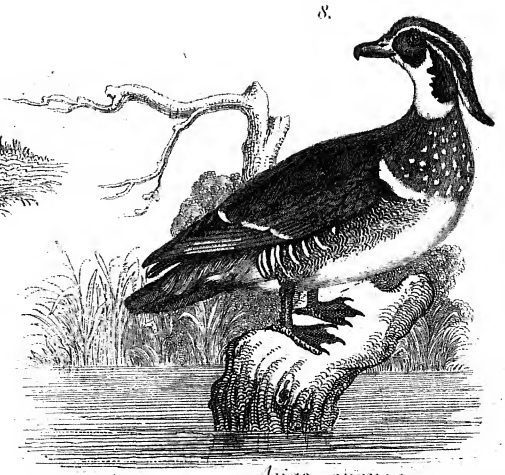
Bill of Mergus.

7.



Mergus cucullatus.

8.



Anas sponsa.

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Geo. Aikman, Sculpt.

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